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AN EVALUATION OF THE RESULTS OF STOCKING IMPORTED COTTONTAIL RABBITS IN NEW YORK STATE[1]

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ABSTRACT

For some years prior to 1939 the Conservation Department imported cottontail rabbits for release in various parts of the State. This practice was terminated in 1939 but, beginning in 1942, sportsmen's clubs were issued permits to make importations.

To evaluate the results of such stocking a study was made, using 12 representative areas widely distributed throughout the major rabbit range of the State. Contracts were let for delivery of rabbits from a midwestern state. During the winter of 1947-48 the number released totalled 2,234, while the following winter 4,438 were liberated.

Releases were made during the open season in order to learn what returns might be realized in terms of direct hunter take. Based on data from four representative areas, it was estimated that hunters recovered 8.6 per cent of the rabbits stocked during the gunning season. Box-trapping data for portions of two areas indicated a calculated survival into the breeding season of less than 13 per cent. The cost of each rabbit shot or surviving into the breeding season was $6.98.

Studies of post-season releases showed that the increase in population on two stocked units of an area was not significantly different from that on an unstocked unit after one full breeding season. Thus it was demonstrated that lack of breeders was not a factor limiting rabbit abundance.

It was concluded that release of imported rabbits, either during or after the open season, is decidedly uneconomical and that very little improvement in hunting opportunity can be expected for the money spent.

During the 1920's the Conservation Department initiated a policy of importing cottontail rabbits from the Mid-west. Several thousand were purchased during the periods 1925-27 and 1932-37, and distributed to game clubs for release. In 1939 a ban was placed on further importations because of a reported epidemic of tularemia among rabbits in the source states. The ban was lifted in 1942 and

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sportsmen were permitted to make importations under permits issu by the Department. Following this there was a steady increase numbers of rabbits purchased, as many as 10,597 being imported one year.

The substantial cost of the rabbits caused sportsmen to seek return to a Department-financed program. This pressure prompt an investigation of the benefits, if any, that might be expected fr further stocking. The study was begun in 1947.

PROCEDURE

Possible benefits from stocking imported rabbits fall in two ca gories: the immediate contribution to hunting opportunity duri the season of release; and the subsequent contribution of surviv and progeny (from either in-season or post-season stocking) duri succeeding years. In order to evaluate these contributions, expe mental releases were made both during and after the open seasons 1947-48 and 1948-49 on a variety of areas over the State (Table 1).

Procurement of Rabbits

Bids were solicited and contracts let for delivery of 5,000 cottont rabbits during the winter of 1947-48. The rabbits were to be deliver on a trap-run basis, without regard to sex. Unfavorable weath conditions in the source state disrupted schedules and also resul in receipt of less than half the number ordered.

Another order for 5,000 rabbits was placed for the winter 1948-49. Deliveries were scheduled between November 15 and Decem 20 for the hunting season liberations, and during early February the post-season releases. This schedule was adhered to, with mi exceptions. All shipments except one were made in equal numb of each sex, with the sex of each animal marked on the crates.

Release Areas

Twelve areas, representative of the major rabbit range of State, were selected for the study of liberations of imported st (Figure 1). Selections were made on the basis of availability of f and cover, absence of landowner opposition to the liberations, a absence or scarcity of posted lands, orchards, nurseries, or commer truck farms. Areas on which releases were to be made during open season were located near large cities, in anticipation that he hunting pressure would be exerted on the released stock.

Date of liberation	Number shipped	Mortality during shipment		Additional dead at liberation	Total mortality prior to liberation (per cent)	Number liberated			Number release points used	Area
		Number	Per cent			Male	Female	Total		
In-season liberations, 1947-48										
December 23	672	69	10.3	4	10.9	....	....	599	32	Newburgh
January 15	576	7	1.2	13	3.5	....	....	556	27	Baldwinsville
Total.....	1,248	76	6.1	17	7.5	....	....	1,155	59	
Post-season liberations, 1947-48§										
January 18	576	53	9.2	4	9.9	....	....	519	38	Unionville
January 31	576	12	2.1	4	2.8	....	....	560	18	Elmira
Total.....	1,152	65	5.6	8	6.3	....	....	1,079	56	
In-season liberations, 1948-49										
November 16	564	10	1.8	11	3.7	138	138	276†	12	Boston
						121	122	243†	7	Clarence
November 18	564	12	2.1	2	2.5	235	232	467	17	Caledonia
November 19						41	42	83		
November 22	564	13	2.3	1	2.5	274	276	550	19	Watertown
November 29	564	10	1.8	4	2.5	274	276	550	12	Utica
December 3	564	11	2.0	0	2.0	272	281	553	16	Newburgh
December 7	564	32	5.7	7	6.9	268	257	525	17	Elmira
December 11	564	14	2.5	12	4.6	268	270	538	14	Binghamton
December 14	564	33	5.9	5	6.7	265	261	526	17	Baldwinsville
January 6	131‡	4	3.1	0	3.1	63	64	127	4	Unionville
Total.....	4,643	139	3.0	42	3.9	2,219	2,219	4,438†	135	
Post-season liberations, 1948-49										
February 2	204	18	8.8	37	27.0	....	101	101°	5	Albany (Voorheesville unit)
February 4	284	20	7.0	29	17.3	61	66	127°	5	Albany (New Salem unit)
Total.....	488	38	7.8	66	21.3	61	167	228	10	

* Total rabbits liberated, 6,900; 5,593 during hunting season, 1,307 after hunting season.
§ Although liberation dates actually were late in the hunting season, circumstances dictated a more logical classification as post-season liberations.
† A total of 564 was shipped in this consignment; however, 24 disappeared during tagging operations.
‡ This was an extra shipment made to compensate for the rabbits that were dead on arrival in previous shipments.
° Only part of the rabbits received in these consignments, and surviving at time of liberations, were placed on the study areas.

Marking

All rabbits were marked with serially numbered ear-tags pri to release. A large sample of the trap-run rabbits was sexed a no statistically significant difference was found in the numbers each sex received. In the shipments where sex was indicated on t crates spot checks were made to insure accuracy.

In order to expedite the releases a crew met each shipment it arrived via Railway Express, and tagging operations began as so as the rabbits could be transferred to working quarters. Members local sportsmen's groups, district game management personnel, a game protectors assisted project personnel in tagging and stocki operations.

Release Methods

In most instances the rabbits were trucked to liberation si immediately after tagging was completed. The number released each site was determined by the extent and quality of the cover. T animals usually were allowed to "escape" from the crates.

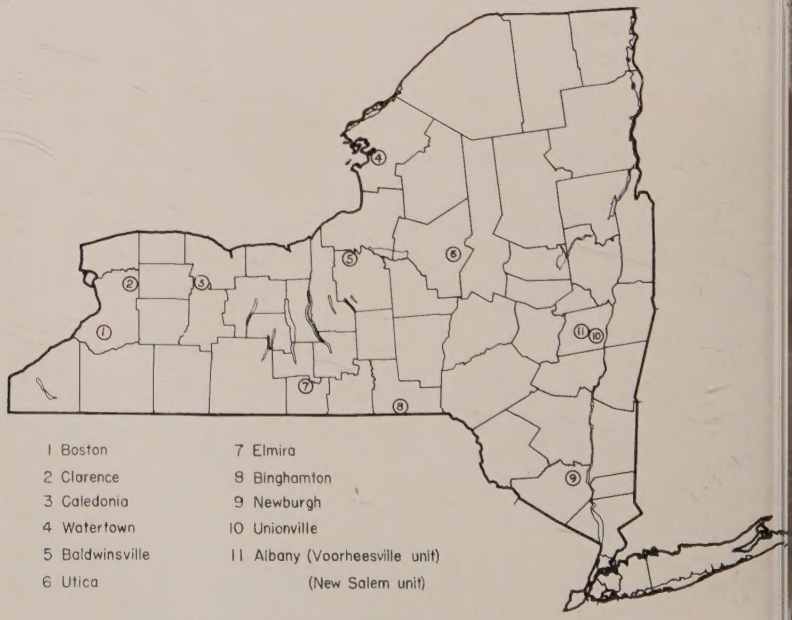
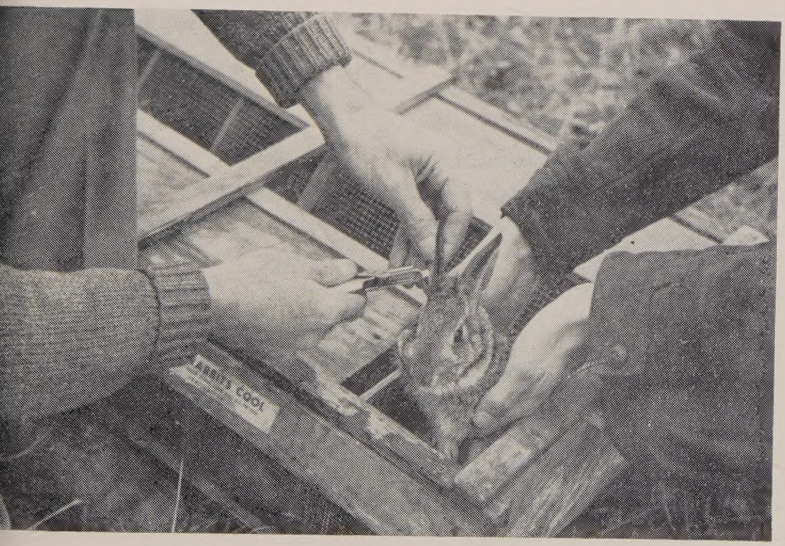


Figure 1. Areas used for experimental cottontail rabbit liberations.

Type of shipping crate used.



Applying ear tag to imported cottontail rabbit.

Each release site was plotted on a map of the liberation area. Ea tag numbers, posted on each crate during the tagging operation, we recorded for each release site.

Tagging, transportation, and release required a minimum of hours for each shipment, usually longer. Rabbits received at nig usually were held until daylight in order to facilitate locating an plotting the release sites.

Collection of Data

In areas where rabbits were released during the hunting seas news items were supplied to local newspapers and, in some cases, radio stations. These briefly explained the objectives of the study, a well as the general location of the study areas, and requested coopera tion in returning ear-tags.

Several methods of soliciting or recording information concernin the fate of liberated rabbits were employed in addition to the gener requests in the press.

Hunter Report Cards Stamped postal card questionnari were mailed to all rod and gun clubs and to many individual hunte in the vicinity of the in-season release areas. Game protectors di tributed cards to hunters in the field.

Field Surveys Searches were conducted in the vicinity some release sites at various intervals after the rabbits were freed i an effort to find carcasses of any that had died or been killed b predators. Only limited surveys of this type could be made in are where rabbits were released during the hunting season, since the tim between shipment arrivals was short and the liberations were mad at widely separated points throughout the State. A thorough coverag was made of all release sites following the post-season liberations 1948-49.

Box-trap Surveys Treadle-type box traps were used to ca ture rabbits in the vicinity of selected release points in order to g an index to survival for the imported rabbits, their relationship to th entire rabbit population, and their contribution to the over-all popul tion. Traps were set in the most likely looking situations and we located 50 to 100 yards apart in a geometric pattern with allowanc for the location and amount of good cover. All traps were numbere and their locations were plotted on maps of the areas. The territo

rapped varied in size but usually included a minimum radius of about quarter mile from each release point censused.

All rabbits captured were released at the trap site after the esired data were recorded. Native rabbits were tagged for later dentification. Data recorded in all instances included trap number, ex, ear-tag number and, in the case of females, breeding condition s determined by palpation and by the condition of the mammae.

Trapping operations to record survival of potential breeders were arried out at selected release sites on a few areas, some of which had een stocked during the hunting season and some after. The two tocked units and the control unit on the Albany study area, on which he major study of post-season liberations was made, were trapped rior to stocking. These units also were trapped in the spring follow- ng stocking to determine survival, and again in the fall to determine ne contribution of imported rabbits to total abundance.

Other Surveys Volunteer bag-check stations were estab- shed on the Albany study area during the fall following release in he hope of recording from hunters any survivors missed in box-trap urveys.

An unsuccessful attempt was made following post-season libera- ons to recover rabbits from underground dens with the aid of ferrets. Jnusually mild weather conditions probably were responsible for the oor success attained.

FINDINGS

The rabbits imported in 1947-48 did not arrive as scheduled, nd totalled less than half the number ordered. Four shipments were eceived, one in late December and three in late January. Since ie cottontail rabbit hunting season closed January 31, there was ttle time in which to test any benefits of stocking for the gun. nusually severe weather conditions further reduced the opportunity measure hunter returns, and few tag recoveries were recorded. onsequently, the last two shipments (the only ones which furnished rvival data) were considered as post-season liberations.

In 1948-49 the liberations took place essentially as scheduled. en areas were stocked early in the gunning season, and two units the Albany study area were stocked after the close of the hunting ason.

Effect of Liberations Made During the Open Season

One of the major objectives of the study was to determine th effect of liberating imported rabbits during the open season, wit respect to both their immediate contribution to hunting and the survival as breeders.

Immediate Contribution to Hunting The liberations mad during the open season of 1948-49 were the only ones which produce data directly relating to the value of such stocking for increasin hunting opportunity. Combined data from the 10 liberation area showed a total known hunter kill of 220 rabbits, or 5 per cent of th number released (Table 2). The range of returns from individu areas was 0.8 to 15.4 per cent. The total kill from each area appa ently bore no relationship to the number of hunting days remainin after liberation, probably because of disproportionate hunting pressur Insufficient information was obtained for computing an index of ma hours hunted or comparing the relative take of imported and nativ rabbits.

Table 2. Known Hunter Take of Imported Rabbits Liberated Durin the Open Season of 1948-49

Area	Date of liberation	Number days open season remaining	Number liberated	Hunter take	
				Number	Per ce
Boston	November 16	76	276	9	3.3
Clarence	November 16	76	243	32	13.2
Caledonia	November 18–19	74	550	18	3.3
Watertown	November 22	70	550	6	1.1
Utica	November 29	63	550	29	5.3
Newburgh	December 3	59	553	11	2.0
Elmira	December 7	55	525	19	3.6
Binghamton	December 11	51	538	83	15.4
Baldwinsville	December 14	48	526	4	0.8
Unionville	January 6	25	127	9	7.1
Total			4,438	220	5.0

On the Binghamton, Caledonia, Clarence, and Utica are abnormally heavy hunting pressure, reported by game protectors an sportsmen, undoubtedly resulted in a larger harvest than would ha occurred had the liberations not been so widely publicized. Of th 1,881 rabbits liberated on these areas, 8.6 per cent were reporte taken. It is believed that the increased hunting pressure compensate in part at least, for failures to report recoveries of tagged rabbits an

that the average hunter take reported for these areas is representative of what may be expected generally under normal stocking conditions.

A significant number of complaints was received regarding the edibility and sporting quality of imported rabbits taken for at least the first week following release, including reports that hunting dogs were seen catching live rabbits and that a few rabbits shot were discarded due to a bluish coloring of the flesh. These were obvious indications that some rabbits taken by hunters were in such poor physical condition that they probably would have died later as a result of the cumulative shocks of importation.

Most of the imported rabbits recovered were shot within the first three weeks after release. Of the 183 (from all areas) for which the dates of recovery were known, 61 were recovered during the first week. By the end of the third week 135, or nearly three-fourths of the total, were accounted for.

Weather conditions, contrary to normal expectancy, were unusually mild and had no discernible discouraging effect on hunters throughout the open season. Consequently, lack of hunting pressure probably can be discounted as a factor in reducing the take of imported rabbits as the season progressed.

TABLE 3. CUMULATIVE RATIO OF IMPORTED TO NATIVE RABBITS REPORTED TAKEN ON ALL AREAS DURING SUCCESSIVE WEEKS AFTER LIBERATION*

Respective week after liberation	Number of reports	Rabbits taken		Cumulative ratio (imported : native)
		Imported	Native	
1	22	63	25	2.52 : 1
2	12	16	6	2.55 : 1
3	5	7	11	2.05 : 1
4	2	4	6	1.88 : 1
5	5	16	6	1.96 : 1
6	1	1	0	1.98 : 1
7	4	8	14	1.69 : 1
8	2	3	2	1.69 : 1
9	0	..	..	..
10	0	..	..	..
11	1	0	3	1.62 : 1

* Based on reports of imported rabbit recoveries which also listed the take of native rabbits, even though negative in some cases.

The greater susceptibility to hunting of recently released imported rabbits is clearly shown in Table 3. These data were taken from

records of recoveries where the take of native rabbits also was noted Unfortunately, most hunters failed to report except when a tagged rabbit was taken, thus eliminating the possibility of making a direct comparison based on the total take. The ratio of imported to native rabbits taken shows a steady decline as the season progressed. A chi-square test of the data through the eighth week showed them to be statistically significant at the 1 per cent level. Thus, the quality of sport furnished by the imported stock was poorer than that provided by native rabbits.

Although the imported rabbits comprised essentially equal numbers of the two sexes, there was an appreciable difference in the sex ratio of those shot by hunters. Of the 220 reported shot, 190 were identified by tag number and thus were of known sex. Of these, 112 were males and 78 were females. The reason for this wide variation was not apparent. Weather conditions during the experiment were not severe enough to cause females to "hole up" for any extended length of time. Nor does there seem to be any evidence that females succumb to shock more easily at the time of release. Langenbach and Beule (1942) reported no difference in mortality between sexes in studies of imported rabbit liberations in Pennsylvania. Furthermore, post-season surveys during the present study showed equal numbers of each sex among rabbits found dead or caught in box-traps.

Survival to the Breeding Season As a measure of the number of rabbits which survived through the hunting season and into the breeding season, portions of two areas were censused. Four release points were box-trapped on the Newburgh area, and three on the Clarence area. Two of the sites on the Newburgh area (on Section B) were trapped from February 26 to March 14, and the other two (on Section A) from March 23 to April 14, 1949. All three release points on the Clarence area were trapped from April 6 to May 19, 1949. A total of 23 imported rabbits (11 males and 12 females) was recovered from the two areas. During the same period 58 native rabbits (35 males and 23 females) were trapped. These figures represented a minimum survival of 7.8 per cent on the Newburgh area and 9.7 per cent on the Clarence area, or an average of 8.6 per cent of the 266 rabbits liberated on the portions censused.

In order to evaluate total survival, an estimate was needed of the number of imported rabbits that evaded capture during trapping operations. This was done by using a variation of the Lincoln Index

for computing total populations. The number of rabbits missed was calculated by applying the following equation:

$$x = \frac{ay}{b}$$

in which,

x = number not trapped during per-census period

y = number trapped and released during pre-census period

a = number trapped during census period that had not been taken during pre-census period

b = number retrapped during census period that had also been taken during pre-census period

In applying this method of calculation, the interval at each site during which most of the trapping success was achieved was selected as the trapping period. Then, in each case, the mid-point was designated as the division between the pre-census and the census periods. Thus, the data were treated similarly even though three different time intervals were involved. Since most captures were made during the first few days after trapping began, this point of separation allowed a sufficient census period to indicate a ratio large enough to be significant. Accordingly, the periods on the two areas were as follows:

	Pre-census	Census
Clarence area	April 8-19	April 20-30
Newburgh area, Section A	March 23-April 3	April 4-11
Section B	February 26-March 5	March 6-11

The trapping data are presented in Table 4.

In using these data to determine the total surviving population of imported rabbits the calculations might be based either on those pertaining to imported rabbits only or on the total for imported and native rabbits combined. The latter would involve an adjustment for the proportion of imported stock present, derived from the ratio of the two types among all the rabbits trapped. In view of limitations involved in each method, the data were analyzed in both ways for comparison.

Table 4. Trapping Data Used in Calculating Survival of Imported Stock Liberated During the Open Season

Item	Clarence area		Newburgh area				Total	
			Section A		Section B			
	Native	Imported	Native	Imported	Native	Imported	Native	Imported
Pre-census								
Killed in trap	..	1	..	..	1	2	1	3
Marked and released*	19	9	14	3	6	5	39	17
Census								
Previously trapped in pre-census period	3	4	4	..	6	2	13	6
Not previously trapped	6	..	3	..	5	2	14	2
Post-census§								
Number trapped	3	1	1	..	..	..	4	1
All periods								
Number separate individuals trapped	28	11	18	3	12	9	58	23

* Native rabbits were marked when trapped; imported rabbits had been marked at time of release, but tag numbers were noted for those trapped.

§ Represents trapping done after the census period.

Based on imported rabbits only, the data for the two areas were combined because of the small number taken during the census period. Substituting in the equation and solving for x indicated that six had been present during the pre-census period in addition to the 17 that were trapped and released; three others had also survived but died after being trapped. Although 266 had been liberated, correction[2] for the proportion that probably moved off the trapped sections prior to census reduced the number used for calculation to 227. On this basis, a survival of 11.5 per cent was indicated. Since the total of 23 imported rabbits recovered equalled the number calculated, the survival figure obtained by this method is probably conservative.

Using the combined figures for imported and native rabbits, and again substituting in the equation, the values of x were 52, 30, and 21 for the Clarence area and the two sections of the Newburgh area, respectively. When the rabbits killed during trapping were added the figures became 53, 30, and 24, respectively. From these, survival was calculated as shown in Table 5. On this basis, an average survival of 13.2 per cent was indicated.

TABLE 5. CALCULATION OF SURVIVAL OF IMPORTED RABBITS BASED ON COMBINED TRAPPING DATA FOR BOTH NATIVE AND IMPORTED STOCK

Item	Clarence area	Newburgh area		Total
		Section A	Section B	
Total calculated population	53	30	24	107
Proportion of imported stock*				
Per cent	28.2	14.3	42.9	28.4
Number	15	5	10	30
Calculated survival				
Number liberated	113	72	81	266
Corrected for movement off area (less 14.7 per cent)	96	61	69	227
Survival (per cent)	15.6	8.2	14.5	13.2

* Derived from totals in Table 4.

The trapping data (Table 4) suggested a disproportionate wariness of traps. Of the 23 imported rabbits trapped, 20 (nearly 87 per cent) were taken during the pre-census period. Of the 58 native rabbits trapped, only 40 (slightly less than 69 per cent) were taken

[2] An explanation of the calculation of this factor (14.7 per cent) is given later in this paper.

during the same period. A greater proportion of imported rabbits w recaptured, as compared with native rabbits, although in this ca the difference was not so marked. Thus, it appears that import rabbits were less wary of traps than were the native rabbits.

No allowance was made in the calculations for this difference wariness. Therefore, it is likely that the figures as derived in Tab 5 are somewhat high and that the actual survival fell somewhe between the 11.5 and 13.2 per cent computed by the two methods.

Effect of Liberations Made After Open Season

In order to make a contribution to hunter take over and abo that provided by native rabbits, imported stock liberated after t open season must survive at least to the breeding season, and produ young for the fall harvest. Both the 1947-48 and 1948-49 liberatio

Table 6. Post-season Liberations of Imported Rabbits that Furnish Data on the Effectiveness of Such Stocking*

Area	Date of liberation	Release point	Number liberated		
			Male	Female	Total
Unionville	January 18, 1948§	10	..	..	35
		11	..	..	24
		12	..	..	36
		15	..	..	12
	Total		..	..	107
Elmira	January 31, 1948	1	..	..	81
Albany Voorheesville unit.	February 2, 1949	1	0	33	33
		2	0	24	24
		3	0	22	22
		4	0	11	11
		5	0	11	11
	Total		0	101	101
New Salem unit..	February 4, 1949	1	14	18	32
		2	14	15	29
		3	17	18	35
		4	12	11	23
		5	4	4	8
	Total		61	66	127

* For the Unionville and Elmira areas, only those release points at whi box-trapping was later done and which yielded usable data are listed.

§ The open season closed January 31, but unusually severe weather con tions after liberation of the rabbits prevented hunting of any consequen

yielded data pertaining to the results to be expected from such releases. They involved four areas and are summarized in Table 6 with respect to the release sites that furnished information on this topic.

Survival March 1 was considered the earliest date for survivors to qualify as effective breeders. Box-trapping furnished most of the data, although supplemental information was obtained from hunter surveys.

The last two releases of the 1947-48 season came under the post-season category by chance rather than intent, and plans to profit from them had to be organized hastily. Therefore, the data are not as complete as those for the following year. However, survival data from these surveys proved to be of value, particularly in the light of later studies.

The sector trapped on the Elmira area represented one of the largest concentrations of rabbits liberated at any one release point. Traps were operated between May 3 and July 1, 1948. The effective radius covered by the 24 traps used was about 300 yards from the release point. Of the 81 rabbits released there, seven were recovered during the breeding season, giving a minimum survival of 8.6 per cent.

On the Unionville area, a maximum of 93 traps was used in the trapping period which extended from April 20 to June 30, 1948. Only five imported rabbits were captured, representing 4.7 per cent of the 107 liberated. It is likely that more would have been recovered had it not been necessary to remove six during mid-February. One release site was but 150 yards from a small planting of young fruit trees, although this fact was not known at the time of release. Damage complaints resulted, and box traps were set. Five imported and two native rabbits were trapped and transferred, and a sixth imported rabbit was shot. Had all those removed survived on the area and been recovered during the breeding season a minimum survival of 10.3 per cent would have been recorded.

Survival surveys on the Albany study area were more extensive and complete. This area was made up of three units a minimum of a half mile apart. Two, New Salem and Voorheesville, were stocked with rabbits while the New Scotland unit was used as a control.

Trapping surveys on the Albany area were conducted during three separate periods, i.e., a pre-liberation survey during the winter and two post-liberation surveys, one in the spring of 1949 and one the following fall (Table 7).

A total of 18 different imported rabbits was recovered by box-

Table 7. Summary of Rabbits Trapped on the Albany Study Area 1949

Unit	Native		Imported*	
	Male	Female	Male	Female
Winter period (January 11–31)§				
New Scotland	7	6	..	..
New Salem	5	8	..	..
Voorheesville	10	11	..	..
Total	22	25	..	..
Spring period (April 5–28)				
New Scotland	6	5	..	..
New Salem	13	10	5	5
Voorheesville	14	11	..	8
Total	33	26	5	13
Fall period (September 14–October 14)				
New Scotland	18	15	..	..
New Salem	34	51	1	1
Voorheesville	39	28	..	4
Total	91	94	1	5

* No imported rabbits were released on the New Scotland unit; only femal were released on the Voorheesville unit.
§ This period preceded the time of any liberations.

trapping during or after the breeding season, and another was take by a hunter during the next open season. This represented a minimu survival of 8.3 per cent of the 228 rabbits released on the area. Coun ing native and imported rabbits, 287 individuals were trapped a con bined total of 515 times.

All 18 imported rabbits recovered by trapping were taken fir during the spring trapping period, another indication that they a less trap wary than native rabbits. Six of these were captured aga in the fall survey. Equal survival of males and females occurred c the New Salem unit, where five of each sex were trapped. On th Voorheesville unit, where only females were released, eight we recovered.

Since all imported rabbits trapped were handled during the sprin trapping period, calculations of survival were based on this perio The results are given in Table 8 and indicate a survival of 10.8 p cent for both units combined.

TABLE 8. TRAPPING DATA AND CALCULATION OF SURVIVAL OF IMPORTED STOCK LIBERATED AFTER OPEN SEASON

Item	New Salem unit	Voorheesville unit	Total
Pre-census			
Marked and released*	6	6	12
Census			
Previously trapped in pre-census period	4	4	8
Not previously trapped	4	2	6
Calculation of Survival			
Rabbits present but not taken in pre-census period§	6	3	9
Total imported rabbits on area	12	9	21
Number liberated	127	101	228
Corrected for movement off area (less 14.7 per cent)	108	86	194
Survival (per cent)	11.1	10.5	10.8

* All data pertains to imported rabbits which had been marked at time of release, but tag numbers were noted for those trapped.

§ Computed from equation given under previous topic.

The 14.7 per cent allowance was made for movements beyond the limits of the trapped areas, in spite of the fact that only two imported rabbits were trapped at distances over 440 yards from their release points. Also, although most sections of the study area outside the trapped units were open to hunting, no reports of tagged rabbits were received except from within the limits of the trapped units.

As was done in the case of breeder survival from in-season liberations, a comparison was also made with the degree of survival calculated from the combined data for imported and native rabbits. On this basis survival was slightly higher (13.5 per cent). Because of the apparent lack of trap wariness among imported rabbits, however, this figure probably represents a higher-than-actual survival.

EFFECT ON FALL POPULATION A primary objective of the study of post-season liberations was to measure any increase in hunting potential which might occur the following fall as a result of stocking. Accordingly, total populations were calculated for both the stocked units and the control unit of the Albany study area prior to and following the liberations made. These calculations were based on trapping data in the same manner as previously described. The midpoint of

Table 9. Calculated Total Populations of Rabbits on the Alba Study Area in 1949

Season*	Type of stock	New Scotland unit	New Salem unit	Voorheesvill unit
Winter (January 11-31).	Native	22	27	29
Spring (April 5-28).	Native	13	30	33
	Native and imported	..§	42	42
Fall (September 14-October 14)...	Native and imported	87§	158	135

* Dates represent trapping periods during which data were obtained.
§ No imported rabbits were released on this unit.

Table 10. Comparisons between Stocked and Unstocked Units Albany Study Area with Respect to Population Increa from Spring to Fall in 1949

Unit	Number rabbits trapped			Calculated population		
	Spring*	Fall§	Percentage increase	Spring	Fall	Percentag increase
New Scotland†..	11	33	200	13	87	569
New Salem.....	23	87	278	30	158	427
Voorheesville...	25	71	184	33	135	309

* Does not include surviving imported rabbits on the New Salem and Voorheesville units, nor any juveniles.
§ Includes imported rabbits and their progeny.
† New Scotland unit not stocked.

each trapping period was used to separate the pre-census from t census period. Results are presented in Table 9.

Definite differences in the native population existed between t New Scotland control unit and the two liberation units, due large to physiographical differences. Therefore, no direct comparison populations could be made. Accordingly, comparison was express in terms of percentage increase in the population from spring to fa i.e., one full breeding season (Table 10).

Spring populations given exclude imported rabbit survivors. F population figures include all imported rabbits and their progeny (t latter being indistinguishable from native young), and thus show t fullest possible increase resulting from the releases.

Based on the actual number of rabbits trapped, the percentage increase on one of the stocked units (New Salem) was slightly greater than that on the New Scotland unit where no releases were made. Based on calculated numbers, the rate of increase on the unstocked unit surpassed that on both those that were stocked.

A portion of the New Salem unit of the Albany area.

The reported hunter take provided additional data for calculating fall populations, by using the trapping period for the pre-census count and the hunting season for the census period. On this basis the rate of increase between spring and fall was 577 and 767 per cent for the New Scotland and New Salem units, respectively. This indicated a greater gain on the New Salem unit which had been stocked than on the unstocked New Scotland unit. No calculations were made for the Voorheesville unit because most hunters could not be contacted to learn the number of untagged rabbits taken.

The accuracy of the Lincoln Index method of calculating population decreases as the interval between the pre-census and census periods increases, since many factors may be introduced to upset the indicated ratio of marked to unmarked rabbits. Most of the hunter reports pertained to rabbits shot after December 1. This involved a lapse of about a month and a half between the pre-census trapping

period and the hunter report census period, whereas there was interval when the two halves of a continuous trapping period we used. Therefore, the population figures calculated from trapping a hunter reports combined probably are not as nearly correct as the obtained through trapping alone.

Post-liberation Mortality

Surveys to record mortality of liberated imported rabbits we conducted on three areas. In some sections searchers were hamper by impenetrable brush piles. No accounting could be made for rabb which died in the numerous woodchuck burrows that existed on areas.

Of the 63 rabbits which had been released at two points on t Elmira area on December 7, 1948, four were picked up dead t morning after release. There was evidence that a fifth rabbit h been taken by a predator. Thus, a minimum mortality of 7.9 per ce is known to have occurred in less than 24 hours. This figure w used to derive an estimate of the average mortality within the fi 24 hours after liberation on all areas. It was assumed that the deg of post-liberation mortality would reflect the physical condition the rabbits at the time of release and would vary directly with t mortality recorded prior to liberation. Therefore, the average va for the immediate losses following release on all areas would be the same relationship to the figure recorded on the Elmira area that between the corresponding figures of mortality prior to liberati On this basis, an over-all average minimum loss of 4.5 per cent wit a day following release was calculated.

On the second day following liberations on the Unionville a in January 1948, a reconnaissance was conducted in the vicinity of c release point. Two men followed the trails of a pair of foxes a in 2 hours time, three rabbit carcasses were found. The foxes h worked all available cover thoroughly. No ear tags were found the carcasses which consisted only of hind quarters. The scene a fourth kill was located. Very likely most of these finds represen kills of imported rabbits. Twelve rabbits had been released at t site. Thus, a mortality of 20 to 25 per cent was indicated.

The major effort to determine the extent of early post-liberati mortality was made on the Albany study area in February 1949. a 2-day survey on each liberation unit during the first week followi release 75 ear tags were recovered from rabbit carcasses. The kno

minimum mortality among rabbits amounted to approximately 33 per cent on both units (Table 11). Portions of 14 additional dead rabbits were found, 2 on the New Salem unit and 12 on the Voorheesville unit. However, since no ear tags were found on the remains of these animals, it was not possible to determine whether they were native or imported. No other surveys of this nature were conducted on the area, and no other mortality except hunter take was recorded.

Table 11. Minimum Mortality of Imported Rabbits on the Albany Study Area During the First Week After Liberation as Indicated by Number Found Dead

Unit	Sex	Number liberated	Tagged rabbits found dead	
			Number	Per cent
New Salem	Male	61	22	36.1
	Female	66	20	30.3
Sub-total		127	42	33.1
Voorheesville	Male	0	..	..
	Female	101	33	32.7
Sub-total		101	33	32.7
Total		228	75	32.9

A total of 56 carcasses, which were intact or in which most of the organs were present, was collected for examination[1]. Of these, 29 were from the New Salem unit and 27 from the Voorheesville unit. Scavenging obscured the evidence as to cause of death in many instances, but it was clear that starvation was a primary cause in the majority of cases. Predation was judged to have been the cause of death for at least 12 of the rabbits collected. Of the 47 stomachs examined, 28 showed ecchymoses of the lining. Of 50 rabbits examined for mesenteric fat, 14 had completely utilized their supply.

Factors Bearing on Survival

In order to evaluate the survival figures in terms of normal expectancy, the effects of factors which have an important bearing on survival of imported rabbits were studied, as they related to the stock under observation. These factors included condition of the rabbits

[1] Autopsies were made by Dr. E. L. Cheatum and James R. Reilly, New York State Conservation Department pathologists.

at liberation, the effect of weather conditions, and the effect predation.

Physical Condition of Liberated Rabbits The degree mortality measured from the time of shipment until liberation, used as an index of the relative physical condition of the impor stock at the time of release. For rabbits released during the o season of 1948-49 the values ranged from 2.0 to 6.9 per cent, a averaged 3.9 per cent (Table 1). With respect to stock released a the open season, values of 2.8 and 9.9 were recorded in 1948 a of 17.3 and 27.0 in 1949.

The average mortality for importations by the Conservat Department during eight years between 1927 and 1948 was 6.8 cent. Between 1942 and 1948 sportsmen's clubs imported c 28,000 rabbits and reported average mortality during shipment a prior to release as 5.9 per cent. However, it is known that there w omissions in reports on rabbits imported by sportsmen, and the per cent figure is considered to be low.

It would appear that, in this study, all the rabbits liberated dur the open season were in relatively good condition. Regarding th released after the open season, however, the ones placed on Elmira area were in excellent shape, but those going to the Uni ville area were considerably below average and those going to Albany area were very poor.

Rowe (1941), in his report on commercial rabbit shipments fr Missouri during the period from 1939 to 1941, recorded an estima mortality of 2 to 5 per cent. The shipments were to Pennsylva Maryland, New Jersey, Ohio, and Delaware. In view of the grea distance and time involved in shipments to New York State, 6 to 7 per cent mortality found in the present study appears to h been in line with Rowe's findings. Although the mortality factor rabbits released in February 1949 appears high compared with average, the rate of loss actually was less than the average for t month as recorded over the years.

Weather Weather conditions can have a tremendous ef on the survival of imported rabbits, especially during the first few d following release. In fasting experiments under various weat conditions, Gerstell (1942) found that in "standard winter weath death came in from 5 to 7 days of fasting, with the average surv time being 5¾ days. In the New York experiments, the 6- period following liberation was considered as the "critical perio

The weather was exceptionally favorable for the in-season liberations. Temperatures were very mild, with the lowest reading for the critical period on any of the areas being 16° F., and this after a 5-day period of temperatures of 30° F. or higher. There was no snow of consequence on the ground on any of the liberation days. Food and cover were plentiful and, in view of the absence of snow, easily available.

Normally, at least one or two severe storms could be expected during the portion of winter remaining after all in-season liberations were completed. However, none of the rabbits released during this phase of the study were subjected to extended or unusually severe storms following their liberation. It is evident that the effects of weather, both immediate and cumulative, were much less severe than would be expected in a normal New York State winter.

Weather conditions during and following the post-season liberations in 1947-48 were definitely unfavorable. On the Unionville area it was necessary to make the releases on 12 to 16 inches of snow consisting of 6 to 10 inches of powder on a 6-inch crusted base. During the first week following release, the temperature rose above freezing only on one day, and the minimum temperatures were below zero on four days. The lowest temperature (-21° F.) occurred on the second night after release. The month of liberation averaged 4.8 degrees below normal.

There were 6 inches of light powder on a 6-inch base on the Elmira area at release time. Minimum temperatures the following two nights reached −12° and −15° F., respectively. Average temperatures for the month of liberation were about normal.

With regard to the 1948-49 liberations on the Albany area, weather was favorable. Precipitation was below normal, and only about 1½ inches of snow fell during the month of liberation. Daily temperatures averaged nearly 8 degrees above normal.

Predation The fact that extensive post-liberation surveys could not be made limited the amount of information secured with regard to predation. A few dogs were observed at various release points pursuing and catching rabbits shortly after they had been liberated. Hunters reported dogs catching rabbits as late as the second day after liberation on the Binghamton area.

Cumulative data from surveys following post-season liberations seemed to indicate that predation losses varied greatly between areas. Quite certainly the condition of rabbits and weather conditions pre-

vailing at the time of release directly affected the vulnerability imported rabbits to predation.

In view of the favorable weather, ready availability of cover, a better-than-average condition of rabbits released during the op season of 1948-49, it is logical to assume that predation loss was l than might normally be expected.

Dispersal of Imported Rabbits Following Release

Distances from release points were plotted for each rab recovered where the data could be verified. Most of the data w secured as a result of box-trapping. Hunting and mortality surv accounted for the rest. In cases where rabbits were trapped m than once, the greatest distance from the release point was used calculations.

Following the 1947-48 liberations 34 dispersal records w obtained. Of these, five, or 14.7 per cent (the correction factor u in calculating survival), came from distances greater than one-quar mile. This is believed to be a liberal interpretation, since two of five were recovered slightly beyond that radius. Had they surviv to become available for box-trapping, it is probable that at leas portion of their home ranges would have been within it. The avera distance moved from release points in from 1 to 156 days after libe tion was 275 yards, and more than half the recoveries were made than 100 yards away. In one instance a movement of 2 mi measured in a straight line, was recorded in less than 2 days a release. This was by far the greatest travel recorded for any rab released.

Dispersal data also were obtained by box-trapping on the Clare and Newburgh areas during the period from 84 to 165 days follow liberation in the early winter of 1948-49. Distances travelled w recorded for 26 rabbits, the average being 270 yards. Only th (11.5 per cent) were recovered more than one-quarter mile from release points.

The Albany study area yielded dispersal data from both morta and box-trapping surveys. Of 75 rabbits found dead from vari causes 5 to 7 days following liberation, only two (3 per cent) travelled more than one-quarter mile from where they were relea The average was 113 yards. The 18 imported rabbits trapped 6 185 days after release had moved an average of 223 yards from rel points. Only two (11.1 per cent) travelled more than one-qua mile. Both were also trapped at half that distance or less.

Harassment by predators probably was an important factor in dispersal when it occurred shortly after liberation. Dog tracks were found over one entire unit of the Albany study area at the time of the mortality survey. The average distance travelled from the release point on this unit was nearly double that on the other unit, for rabbits found dead. The difference in dispersal distances of rabbits recaptured by box-trapping was nearly as great.

Any major travels away from release points apparently took place within a very few days after liberation. As evidence, three rabbits which travelled 600, 900, and 3,500 yards from their release points were recovered within 4 days of release. Two others which travelled over one-quarter mile were recovered within 5 to 7 days. Several rabbits which, after a considerable time interval, were box-trapped at greater distances from release points were later taken repeatedly within a small area. From the available data, it appears that, given suitable range and not harassed, imported rabbits tend to remain close to release points and there establish their home ranges. Home range sizes as exhibited by imported rabbits during trapping operations closely approximated those of native rabbits.

Reproductive Behavior of Imported Rabbits

Records of breeding activity were kept for each adult female taken in box-trapping surveys. Pregnancy was determined by palpation. Pregnancies of about 7 days often can be detected by this method, and the chances of error are remote when pregnancy has existed for 11 days or longer. Lactation was detected by noting development of the mammae, and suckling by the matted appearance of the fur around the mammae. The more intensive work following the releases of 1948-49 permitted comparison of the breeding records of native and imported rabbits.

The purpose of liberating females only on the Voorheesville unit was to determine the degree of interbreeding between native and imported rabbits. Both were of the same species, but the Missouri cottontails probably were an intergrade between *Sylvilagus floridanus alacer* and *S. f. mearnsi*. The local rabbits were considered to be *S. f. mallurus* or *S. f. mearnsi*, with the possibility of intergradation.

Of the eight imported rabbits trapped on this unit between April 1 and 28, 1949, all had bred successfully at least once, and four had bred a second time. During the same period 11 native females were caught on this unit. Ten of these were examined and found to have

bred successfully. One escaped before it had been examined. Sin there were no imported males on or near the unit, it is clear that t imported females were bred by native males as freely as were t native females.

Definite information as to the total number of litters per fema per year could not be secured directly, since trapping did not contin through the summer. However, enough catches were made during t 23-day trapping period in April to indicate the interval between litte Three native rabbits were captured in gravid condition at interv of 10, 11, and 12 days, respectively. Each was handled at least on in between, when she was lactating but not gravid. The correspon ing interval for one imported female was 14 days. The stages development of the fetuses in each case indicated, for both native a imported rabbits, that mating had taken place shortly after parturitio

Based on fall captures, most of the young on the Albany area we born on or before September 1. Twelve of the 18 females trapp during the latter half of September were neither pregnant nor lact ing. Six were still lactating, but four of these apparently were longer suckling young. Five very small rabbits (less than 350 gram were caught in late September or early October, indicating that a f litters were born in early September. The latest estimated birth da was September 6. Assuming a 28-day gestation period, the lat successful date of mating in 1949 on the Albany study area w August 9. Estimated dates of birth were derived by reference Beule's (undated) graphs of correlated weights, tarsal lengths, and ag

Cost

With respect to the 1948-49 in-season releases, 4,512 rabbits we purchased at $1.48 each, or a total cost of $6,677.79. Of these, 1 in the scheduled shipments in November and December were de on arrival but were compensated for, to the extent of 127 receiv alive, in an extra shipment (Table 1). In addition, 42 died betwe the time of arrival and that of release, and 24 disappeared duri tagging operations. Thus 4,438 were actually liberated.

Of those liberated, 21.8 per cent[4], or 967, were taken by hunt or survived as breeders. Thus, in terms of net results the "effectiv rabbits cost $6.91 each.

[4] Comprises the 8.6 per cent taken by hunters and the 13.2 per cent survi to the breeding season.

DISCUSSION AND CONCLUSIONS

The highest returns recorded for the various stocking efforts were registered from the 1948-49 in-season liberations. Except as indicated, the following discussion will pertain to those liberations.

Data from this study show that 8.6 per cent of the rabbits liberated during the open season were taken by hunters during that season, and that 13.2 per cent survived to the breeding season. It is recognized that not all the imported rabbits taken by hunters were reported. Nevertheless, a high degree of cooperation was realized on the four areas on which the hunter take value is based, and a greater than normal hunting pressure occurred on these areas as a result of publicity given the liberations. Also, based on normal mortality known to occur following stocking, as well as on hunter comments about the poor condition of some rabbits taken soon after release, it is probable that a few recorded as taken by hunters would have succumbed to other causes if they had not been harvested so quickly. In view of this, it is believed that the hunter-take figure is a reasonable representation of the take which would have resulted from normal hunting pressure. The survival figure is believed to be liberal.

Certain factors favored above-average survival. Taking shipment mortality as the criterion, the quality of the imported stock was high—undoubtedly higher than in "run of the mill" shipments which might be expected from a variety of dealers. Weather conditions both during the "critical period" and throughout the winter following liberations were unusually mild. Thus, the survival recorded in this study must be considered to have been greater than normally could be expected. It seems apparent that 20 per cent would be a liberal figure to represent both rabbits taken by hunters and those surviving as breeders. In terms of cost, this means a return of 20 cents on each dollar invested, including capital.

The area affected to any appreciable degree by any one release had a radius of less than one-quarter mile, or an area of about 126 acres. Since 135 release points were used, the total area effectively stocked was about 17,010 acres. The total of 967 functional[5] rabbits thus represented 5.7 per 100 acres.

A conservative estimate of the amount of suitable rabbit habitat in the State was determined as one-tenth of the total farm area, or 1.87 million acres. To stock this area with the same density of functional

[5] The term "functional" is used to designate those rabbits which either were taken by hunters or survived as breeders.

rabbits as in the study would result in a hunter take of 42,049 stock rabbits and a breeding season survival of 64,541. On the basis of 20 per cent return, a total of 532,950 rabbits would have to be pu chased at a cost of $788,766, using the same unit price as in 1948-4

The tremendous expenditure which would be necessary to ma an appreciable direct contribution to hunter take on a statewide ba may be illustrated in another way. In the 8-year period from 19 to 1946, rabbit populations provided good hunting during the fi four years, and poor hunting during the last four years. The avera reported kill from 1939 to 1942 was 777,769, while from 1943 to 19 it was 353,220. Half the difference between these two figures assumed to be the point where good rabbit hunting graded into po hunting. In other words, an additional kill of 212,275 rabbits wou have converted a poor season into a good one. To have made this difference through liberation of imported stock would have mea the purchase of 2,468,314 rabbits, based on the 8.6 per cent rate return to hunters derived from data gathered during this study. T cost would have been more than $3,000,000 at the prices paid 1949. Second year returns of stocked rabbits are insignificant a would alter these figures but slightly.

It should be pointed out that the more liberal interpretation the data resulting from this study was taken wherever two or mo choices were indicated. Coupled with the fact that weather conditio were unusually mild (the winter months of December, January, a February, 1948-49, were the fourth warmest recorded by the Weath Bureau in New York State) it must be concluded that the import tion and release of cottontail rabbits during the open season is neith effective nor economical as a means of providing better hunting.

Data obtained both from in-season and post-season liberatio indicated a survival to the breeding season of about 15 per cent und favorable conditions. However, whatever benefits might seem accrue from such survival and the apparently increased reproducti potential lose their significance when considered in terms of increa in population over and above that contributed by native rabbits. shown by the comparison of populations on both stocked a unstocked units of the Albany area, survival did not mean a propo tionate increase in total population. In spite of the fact that survivors on one unit were productive females the rate of increa on the unstocked unit was as great as that on the stocked unit. T obvious conclusion is that under normal circumstances the reproducti

otential of native rabbits is adequate to fill to capacity the available abbit habitat and that, as shown in this study, imported survivors nay replace but do not supplement native rabbits on stocked areas.

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BAIT FISH PRODUCTION IN NEW YORK PONDS[1]

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ABSTRACT

Bait fish were stocked in 95 farm ponds in central New York State duri the years 1953 to 1955. Six species were tested individually in one or mo ponds. Three, the golden shiner, white sucker and fathead minnow, we found to be suitable for propagation in New York ponds.

Adult golden shiners were stocked at rates of 200 to 1,880 per ac Population estimates during the second growing season demonstrated that t number of golden shiners present was governed more by physical and biologi environment than by stocking rate. The weight of the standing crop at t end of the first growing season averaged 167 pounds per acre compared w 362 pounds per acre in August of the second growing season. The avera yield from fertilized ponds in the second growing season was nearly 20,0 shiners over 3 inches long.

Suckers were stocked as advanced fry in 18 ponds at rates of 50,000 231,000 per acre. Survival of fry to fall ranged from 2 to 71 per cent a averaged 24 per cent. Growth rate in fertilized ponds was negatively correlat with population density. Yield during the first growing season averaged 2 pounds per acre including that for three ponds stocked with eyed eggs. seven ponds where young were overwintered, their mean length increased 0. inch and the increment in population weight was 92 pounds per acre fr fall to the following May.

Adult fathead minnows were stocked in eight fertilized ponds at rates 600 to 2,000 per acre. A relatively small proportion of the first year's hat of young reached salable size of 1.8 inches by fall, and the average yield fro the eight ponds was 12,140 per acre. Seven ponds managed for a 2-year peri yielded an average of roughly 50,000 minnows of salable size per acre.

Obtainable supplies of desirable bait minnows in New York lak and streams appear inadequate to meet current angling needs. preliminary survey of bait dealers in 1952 indicated shortages pike-size bait (over 4 inches) in the spring and limited supplies smaller bait fish during the summer months. Small minnows we usually available from lakes and rivers during the spring and fall, a were marketed at low prices. Information from this survey was us to design a bait propagation study which was carried on during t years 1953 to 1955.

The golden shiner *(Notemigonus crysoleucas)*, white suck *(Catostomus commersonnii)*, fathead minnow *(Pimephales promela* silvery minnow *(Hybognathus nuchalis regius)*, bluntnose minn *(Pimephales notatus)* and chub sucker *(Erimyzon oblongus oblongu*

[1] A contribution of Federal Aid in Fish and Wildlife Restoration Project F-4- The author is indebted to many pond owners whose cooperation and assistan made possible the collection of data on fish production, and wishes to ackno edge Alfred W. Eipper and Dwight A. Webster, Department of Conservati Cornell University, for their critical reading of the manuscript and valua suggestions.

ere stocked individually in 95 ponds located in central New York tate. Growth, survival and yield were measured at intervals of 4 > 18 months. The principle objectives were to determine which pecies could be successfully reared for bait in New York and to stablish management methods suited to small impoundments.

Most bait ponds studied were privately owned and similar in esign to farm ponds. Water levels were generally maintained by unoff or ground water, and the ponds were seldom suited to an ntensive type of bait culture. Danger of oxygen depletion made eeding hazardous and a complete harvest of bait fish was frequently npracticable. The ponds were representative of the types currently sed for bait production in New York. Limnological characteristics f New York fish ponds are described elsewhere (Forney, 1957).

METHODS

Pond areas varied from 0.1 to 4.5 acres. To facilitate comarisons between ponds of different sizes, data on standing crops, elds, stocking rates, and fertilization are expressed on a per acre basis.

TOCKING

Brood fish were usually obtained from natural waters. Adult olden shiners, fathead minnows and silvery minnows stocked averged 4.6, 2.5, and 3.5 inches in length, respectively. Sexes were ocked in approximately equal numbers. Adult fish were counted dividually before stocking. The number of young or small yearling[1] sh was approximated from total weight and number of fish per ound.

The white sucker was the only species stocked as eggs or fry. ucker eggs were measured by volumetric displacement of water in a raduated cylinder and an aliquot portion counted. Advanced fry ere reared from a known number of eyed eggs. The percentage of ortality occurring between the eyed egg and fry stages was estimated counting dead eggs on sections of egg trays.

ENGTH AND WEIGHT MEASUREMENTS

Samples of 20 to 200 specimens for length measurements were llected at the time each pond was inventoried, and during interning periods when possible. Collections were made using a 75- or

[1] Young refers to age-group 0 fish, and yearlings to age-group I fish.

150-foot bag seine of ¼-inch-bar mesh except as otherwise state
Total length, from snout to tip of tail with the lobes compresse
was measured to the nearest millimeter. All measurements were tak
on fish preserved in 10 per cent formalin. Original compilations a
analyses were made in millimeters but have been converted to inch
for publication.

Bait fish netted from ponds were weighed in a metal tub su
pended from a spring scale of 60-pound capacity. A count of t
number of bait fish in a 2- to 4-pound sample furnished an estima
of the number per pound. A portion of the same sample was th
segregated into inch size classes to provide data on the proporti
of the population in each length class.

Population Estimates

A complete count of the entire population was possible o
when ponds could be drained. Where draining was not feasib
repeated seine hauls with 75- or 150-foot, ¼-inch-mesh nets we
effective in removing most of the population from small ponds. Bo
seines were 8 feet deep in the center, tapering to 4 feet on the en
with a center bag 8 feet in length. Population estimates were co
ducted on ponds less than an acre in area; consequently, the n
fished most of the pond in each sweep. The number of seine ha

Table 1. Weight of Fish Removed by Seining and the Actual Popu
tion Weight Determined by Drainage

Species	Pond	Catch in successive seine hauls (pounds)						Total pounds seined	Weight remainil (pond drained	
		1st	2nd	3rd	4th	5th	6th		Pounds	Per cen
Golden shiner	6	75.0	22.0	11.0	4.0	..	..	112.0	3.6	3.
	7	42.0	15.0	3.0	..	..	..	60.0	3.0	4.
	8	67.0	6.0	6.5	0.5	..	..	80.0	2.8	3.
	13	62.0	8.5	10.5	4.0	..	..	85.0	6.0	6.
	25	26.0	11.0	3.0	..	..	..	39.0	5.5	12.
	26	25.0	11.0	3.0	..	..	..	40.0	6.0	13.
White sucker	106	37.5	33.5	8.4	1.0	..	..	80.4	1.0	1.
	107	37.0	10.0	7.0	1.0	1.0	..	56.0	1.5	2.
	109	9.2	3.3	1.8	..	..	..	13.3	4.5	25.
	111	80.0	25.0	25.7	9.7	13.0	2.5	155.5	36.5	19.
	112	28.0	11.5	12.5	3.5	4.5	..	60.0	3.0	4.
Fathead minnow	206	52.0	8.4	3.4	..	..	..	63.8	4.2	6.
Silvery minnow	310	34.4	16.1	5.2	1.8	..	..	57.5	7.0	10.

* Per cent of actual population weight.

nade in each pond was determined by the rate and regularity with vhich the catch declined.

The reliability of repeated seining as a measure of population ize was tested by draining 13 ponds (having surface areas of from .2 to 0.4 acre) after seining (Table 1). The total catch by seining vas less than the actual population weight by an average of 7 per ent in six golden shiner ponds and 11 per cent in five ponds contain- g white suckers. In a single pond, seining failed to take 6 per cent f the population of fathead minnows, and in one containing silvery innows the total weight of the catch was 11 per cent less than that f the actual population.

Another test of the adequacy of repeated seining is available from wo golden shiner ponds with duplicate inventories. During the -week interval between inventories, growth in both ponds was negligi- le. Results were as follows:

Pond	Number of seine hauls	Total catch (pounds)
8	4	60
	4	59
4	5	654
	5	637

n each pond, the difference between the two population estimates was ss than 3 per cent of the mean estimated population.

The catch in successive seine hauls usually decreased at a uni- rm rate, suggesting that the regression method developed by DeLury (1947) might provide an estimate of initial population size. In the 3 ponds used to evaluate the effectiveness of seining, the catch in ccessive seine hauls was plotted against the cumulative catch at ie time of each seine haul. A linear regression was computed. The tercept of this regression on the *y*-axis, divided by the slope of the gression line, yielded an estimate of the initial population (Table 2). opulation estimates obtained in this manner were generally lower an the population size to the same extent as the total catch Table 1) and consequently had little advantage over total catch an estimate of the standing crop.

ertilization and Feeding

Pond owners cooperating in bait fish research were asked to

Table 2. Actual Population Weight in Ponds Determined by Drain and DeLury Estimate of Population Weight Based on Cat in Successive Seine Hauls

Species	Pond	Actual population weight (pounds)	DeLury estimate of population weight	
			Pounds	Per cent error
Golden shiner	6	115.6	112.4	− 2.8
	7	63.0	62.6	− 0.6
	8	82.8	79.5	− 4.0
	13	91.0	82.1	− 9.8
	25	44.5	41.8	− 6.1
	26	46.0	42.7	− 7.2
White sucker	106	81.4	89.7	+10.2
	107	57.5	55.9	− 2.8
	109	17.8	15.2	−14.6
	111	192.0	155.2	−19.1
	112	63.0	63.2	+ 0.3
Fathead minnow	206	68.0	63.7	− 6.3
Silvery minnow	310	64.5	59.0	− 8.5

apply 200 pounds of a commercial fertilizer mixture at intervals 2 to 3 weeks between April and September. Cooperators were advis to terminate fertilization if plankton became dense enough to obsc the pond bottom at a depth of 12 to 18 inches. These recommenc tions were followed by a majority of the pond owners. The commerc fertilizer was broadcast from shore along one side of the pond.

Manure or soybean meal was occasionally substituted for co mercial fertilizer. These fertilizers were usually applied in larg quantities and at less frequent intervals than commercial fertilize However, when soybean meal was applied bi-weekly or more oft it was considered a supplemental feed.

FINDINGS AND DISCUSSION

The data for each species of bait fish are presented separatel Ponds stocked with golden shiners were usually managed to produ

[3] Figures given for numbers of young fish stocked, fish harvested and stand crops have been rounded to the nearest 10 fish. Means derived from th figures have been rounded to the same extent. Poundages have not b rounded since weight could be determined accurately when ponds w drained. Actual counts were made of the adult fish stocked. When fry w stocked the numbers were estimated indirectly and these estimates have b rounded to the nearest 1,000.

bass-size bait[4]. The white sucker was reared to meet the demand for summer bass-size bait or spring pike-size bait, and fathead minnows were marketed during the summer as perch-size bait. Silvery minnows, bluntnose minnows and chub suckers were reared in several ponds to determine their value under New York conditions.

GOLDEN SHINER

Perch-size golden shiners are sold in the spring and fall when low water temperatures facilitate the handling of these delicate minnows. Golden shiners over 3 inches in length are reasonably hardy and are sold during the summer as bass-size bait. Information on reproduction, growth, and yield of the golden shiner is based on 21 ponds stocked with adults and 9 rearing ponds stocked with young or yearlings.

Reproduction

Adult shiners were stocked in ponds located at elevations of 400 to 1,900 feet and ranging in total alkalinity from 5 to 200 p.p.m. Young were produced in 24 of the 27 ponds stocked.

Spawning Season and Age at Maturity Spawning began in late May in both 1953 and 1954, and continued through the summer. Fry less than 0.5 inch in length were frequently present in late September.

Yearling male and female golden shiners over 2.5 inches in length were mature by June 15 in three ponds (12, 26 and 27). In the same ponds smaller shiners were immature. Gonad development of yearlings in four other ponds (5, 6, 7 and 8) suggested that sexual maturity would not have been reached until late in the second growing season, although some of these yearling shiners were over 2.5 inches in length. Shiners hatched late in the spawning season may not mature until their third growing season even under favorable growing conditions.

Spawning Success The three ponds in which reproduction was unsuccessful were characterized by Secchi-disc transparencies of consistently under 14 inches and by absence of submergent aquatic vegetation. Survival of adults from the time of stocking to the fall

[4] Throughout this paper, size designations of bait minnows refer to length groups as follows: perch size, 2 to 3 inches; bass size, 3 to 4 inches; pike size, over 4 inches.

inventory in these three ponds (19, 20 and 24) was comparable that in ponds where adults had reproduced. Sex products of norm appearance were extruded from several adults netted from Pond in August. Females in Ponds 19 and 20 were reabsorbing their eg in late September.

Failure of golden shiners to reproduce in the three ponds w probably associated with the absence of filamentous algae and high aquatic plants due in part to low water transparency. Eggs of t golden shiner are adhesive and are scattered over submergent vege tion (Cooper, 1935; Markus, 1939). In the absence of other spawni sites, eggs may be deposited on the pond bottom where they are pr ably subject to high mortality, or retained by the female as observ in Ponds 19 and 20.

Relation between Stocking Rate and Yield Ten por were stocked with adult golden shiners in April and May 1953. T effect of stocking rate on the number of yearling (I+) shiners 1954 is shown in Table 3. The adults were from a common sour thus the potential egg production was directly proportional to t number of adults. Estimates of numbers of yearlings are based inventories conducted after August 1, 1954, so shiners hatched i in the summer of 1953 were large enough to have been taken in t seines used. Population estimates were adjusted, when necessary, eliminate the effect of young hatched in 1954 being present in t seinable population. This was done by determining the percenta of young in the catch using the length-frequency distribution of representative sample. There was little or no overlap in the s distribution of young and yearlings from the same pond.

A portion of the yearling golden shiners was removed fr Ponds 5, 7 and 8 during the summer of 1954. For these ponds theoretical fall population was calculated by adding to the stand crop the number harvested after correcting for natural morta occurring between the time of harvest and fall. In Pond 6, wh was directly adjacent to Ponds 5, 7 and 8, the weekly instantane mortality rate[5] was 0.013. This rate was considered applicable to other three ponds and a uniform distribution of mortality dur the growing season was assumed. As the number of fish harves was not large, the errors in these assumptions do not invalidate co parisons between harvested and unharvested ponds.

[5] Represents a means of expressing mortality as an exponential function (Ricker, 1948).

TABLE 3. NUMBER OF GOLDEN SHINERS STOCKED AND YEARLINGS PRODUCED IN PONDS FERTILIZED AT DIFFERENT LEVELS

Low rate of fertilization					High rate of fertilization				
Pond	Number per acre		Fertilizer		Pond	Number per acre		Fertilizer	
	Adults stocked	Yearlings produced	Pounds per acre	Type		Adults stocked	Yearlings produced	Pounds per acre	Type
1	1,880	24,000	..	..	5	200	62,570	480 2,800	5-10-5 manure
11	1,320	11,790	420	5-10-5	7	620	81,740	890 1,000	5-10-5 manure
3	750	5,770	..	..	8	620	60,400	480 3,800	5-10-5 manure
12	670	13,340	440	10-10-10	6	960	58,520	480 3,800	5-10-5 manure
2	560	11,420	..	..	13	1,000	47,800	480 1,300	5-10-5 manure
Linear regression fitted by least squares to the above data									
$3,480+9.4$ adults					$51,054-16.4$ adults				
Tests of significance of regression coefficients									
$t=\frac{9.4-0}{18.4}=0.5$ ($t_{.05}=3.2$, d.f. 3)					$t=\frac{16.4-0}{21.7}=0.8$ ($t_{.05}=3.2$, d.f. 3)				

From the number of yearlings present in 1954, the ten pon are readily divided into two groups. One group includes thr unfertilized ponds and two ponds which received a small quality commercial fertilizer (Ponds 1, 2, 3, 11 and 12). The other gro (Ponds 5, 6, 7, 8 and 13) was more heavily fertilized. Within t two groups, the number of young surviving to an age of I+ appe to have been independent of the stocking rate. The slopes of regr sion lines fitted to the data from ponds in each of the two groups not differ significantly from zero (Table 3).

An additional three fertilized ponds (21, 22 and 29) were stock with adult golden shiners in May 1954 and inventoried in August 19 The numbers of adults stocked and yearlings produced in these pon are shown in Figure 1, together with data from the ten ponds stock

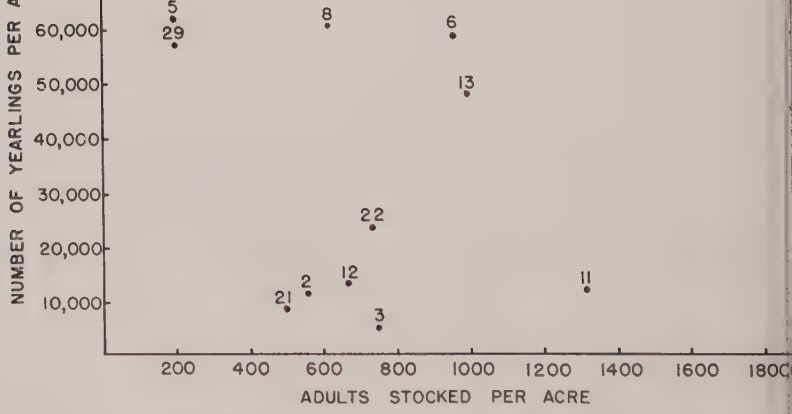
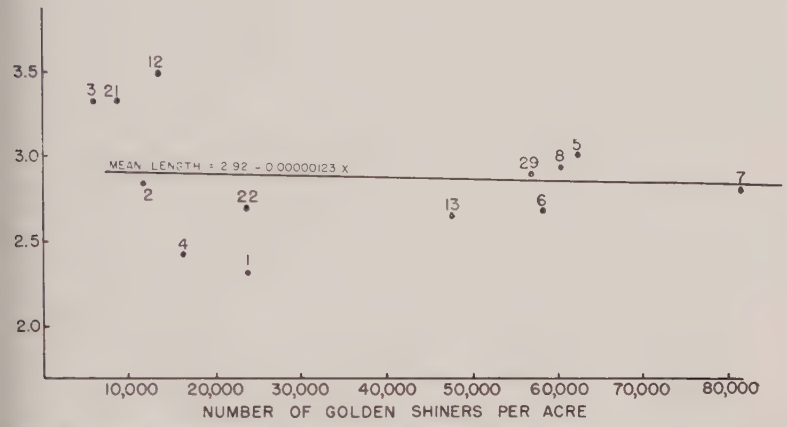


Figure 1. Yearling golden shiners produced in ponds stocked with adults various rates.

in 1953. The standing crop of yearlings in Pond 29 was similar that in the fertilized ponds inventoried in 1954. Ponds 21 and were heavily fertilized but yielded few yearlings. Both ponds w turbid with suspended clay which possibly reduced spawning succe Buck (1956) noted that Oklahoma ponds, turbid with suspended cl generally produced low standing crops of fish.

Information from ponds stocked in 1953 and 1954 indicates th at stocking rates of 200 to 1,880 adults per acre, the number of you

rviving to an age of I+ is controlled primarily by factors of the hysical and biological environment other than the number of adults ocked.



gure 2. Mean length of yearling (I+) golden shiners in August-September plotted against the standing crop of yearlings. Pond number is shown beside each point.

The small number of yearlings in unfertilized ponds compared ith the number in heavily fertilized ponds suggests an adjustment of opulation size to food supply. If true, then growth of fish in the 3 ponds should have been uniform, since growth was determined rgely by the amount of food per fish in these ponds (temperature fferences were small). The mean length of yearling golden shiners nd the number of yearlings per acre in the 13 ponds are shown in igure 2. The mean length, although ranging from 2.4 to 3.5 inches, ecreased only slightly as the population density increased. The ope of the linear regression fitted to the data does not differ signifintly from zero. The tendency for growth to be similar at population ensities of 6,000 to 81,000 yearlings per acre suggests that the survival young to the second growing season is related to food abundance.

URVIVAL

The extended spawning season of the golden shiner makes deterination of mortality rates during the egg and fry stages difficult. he relationship between stocking rate and yield suggests that food mpetition may reduce fry survival. Large yearling populations may so reduce fry survival.

Effect of Yearling Density on Survival of Young F ponds containing yearlings and mature golden shiners were drain and their catch basins were seined with a fine-mesh net to recover young of the current year. Although the number of mature shin in the four ponds varied, it is believed differences in their egg prod tion were of less importance than the number of yearlings per acre determining production of young. This assumption is based on absence of correlation between yield and stocking rate in other po

Table 4. Young Golden Shiners Produced per Acre in Ponds Stoc with Different Numbers of Yearling and Adult Shiner 1954

Pond	Number stocked per acre (spring)		Number of young (fall)
	Adult	Yearling	
26	..*	20,680	76,000
25	..*	22,600	49,800
13	750	59,200§	5,000
6	870	72,200	6,000

* Approximately 10 per cent of the yearling shiners were mature w stocked.

§ Estimated from the fall population, assuming a weekly instantan mortality rate of 0.013 as occurred in Pond 6.

The data of Table 4 indicate that few young survived to fal ponds where a large number of yearlings were present. Redu production of young is evident for Ponds 6 and 13 where the num of yearlings is a minimum estimate of the number of young produ the preceding year when brood fish were initially stocked. The sma yearling populations of 22,600 and 20,680 per acre in Ponds 25 26 did not seem to seriously curtail the production of young.

Survival of Fall Plantings of Young Golden shiners to 2.0 inches long were stocked in five ponds in October 1954. T ponds were inventoried during September-October 1955. Surv over the 11- to 12-month period averaged 71 per cent (Table Differences in survival rates were small, although ponds were sto at rates of 28,710 to 67,000 young per acre. Mortality over wi and during the second growing season is apparently not stro dependent upon density.

Survival of Yearling Golden Shiners Data on the surv of golden shiners between spring and fall of the second gro

ABLE 5. SURVIVAL OF YOUNG GOLDEN SHINERS STOCKED IN OCTOBER 1954 AND REMOVED IN SEPTEMBER-OCTOBER 1955

Pond	Number stocked per acre	Number removed per acre	Per cent survival
9A	28,710	19,190	67
8A	35,650	25,970	73
6A	42,350	30,600	72
7A	46,000	30,810	67
26A	67,000	53,470	80
ean			71

ABLE 6. SURVIVAL OF YEARLING GOLDEN SHINERS OVER A 3- TO 4-MONTH SUMMER PERIOD IN FIVE BAIT PONDS IN 1954

Pond	Initial yearling stock (per acre)	Final yearling stock (per acre)	Per cent survival	Weekly instantaneous mortality rate
6	72,200	58,500	81	0.013
25	22,600	20,500	91	0.007
26	20,700	16,000	77	0.019
27	12,000	10,900	91	0.006
28	9,100	8,000	88	0.007
ean			86	0.010

ason were obtained from five ponds stocked with 2.0- to 2.5-inch arlings in the spring of 1954. These ponds were drained after out 4 months. Survival during the 4-month period of the second owing season averaged 86 per cent (Table 6). The mean weekly stantaneous mortality rate of 0.01 corresponds to an annual survival te of 60 per cent.

ROWTH

Growth of the golden shiner was determined from the mean served length in samples of 40 to 200 specimens. Most samples ere collected with ¼-inch-mesh seines, and many young shiners ere too small to be retained. The subsequent recruitment of late tches into the "seinable" population during the second growing ason causes an exaggerated decrease in growth rate with an increase age. However, such samples do serve as a basis for determining e length of time required to rear golden shiners to bait size.

Length of Growing Season A comparison of the me lengths of golden shiners from ponds netted in the fall and again the spring (Table 7) indicates the growth increment between the sampling periods was generally negligible. The slight differences mean length between fall and spring samples in Ponds 11, 13, a 14 are not statistically significant. Growth of golden shiners New York ponds appears limited to the approximately 6-month peri between early May and late October.

Growth Rate Mean total length of golden shiners in ponds ranged from 1.71 to 2.88 inches by the end of the first growi season (Table 7). Some golden shiners attained a size suitable perch by late summer or fall of their first year in all ponds. On six of the 18 ponds produced an appreciable number of bass-s shiners in the first growing season. By August of the second growi season the range in mean lengths of yearling golden shiners fro 13 ponds was 2.36 to 3.55 inches with a class mean of 2.90 inch These data indicate that approximately half the golden shiners w reach bass size by mid-summer in ponds where most or all of t preceding year's hatch is held for additional growth. Selective remov of bass-size shiners at intervals during the second year would probab increase the proportion of the first year's hatch reaching that si Restocking of small golden shiners in rearing ponds is an alternati means of producing bass-size bait.

Young shiners 1.0 to 2.0 inches in length were stocked in fi ponds during October 1954. The mean lengths of samples collect from these ponds during the 1955 growing season are plotted agai time in Figure 3. Spring and early summer samples were collect with a ⅛-inch-mesh seine which retained small yearlings; ¼-inc mesh nets were employed in late summer. All five ponds were fe tilized, and soybean meal was fed in Pond 26A at a uniform ra between May and September.

Growth rate between June and September was uniform in Po 9A, but tended to decrease in Ponds 7A and 26A. This late summ decrease in growth rate may be attributable to the higher stocki rates of 46,000 and 67,000 shiners per acre in Ponds 7A and 26 respectively, compared with 28,710 per acre in Pond 9A. A l summer decrease in growth rate was not apparent in Ponds 6A a 8A, stocked with 42,350 and 35,650 young per acre, respectively. Bo ponds were seined in midsummer and approximately half the standi crop of yearlings removed.

TABLE 7. MEAN TOTAL LENGTHS OF GOLDEN SHINERS IN PONDS INITIALLY STOCKED WITH ADULTS IN APRIL AND MAY OF 1953 AND 1954

Year stocked	Pond	Mean length in inches at month of capture											
		Young			Yearling								
		August	September	October	March	April	May	June	July	August	September	October	
1953	1	..	1.84	..	..	..	..	..	..	2.36	..	2.42	
	2	..	1.71	..	..	..	2.20	..	..	..	2.87	..	
	3	..	2.39	..	..	..	..	..	..	2.98	..	3.37	
	5	..	..	2.37	..	..	..	..	2.80	..	3.06	..	
	6	..	..	2.33	2.35	..	..	..	..	2.74	..	..	
	7	..	..	2.37	..	..	..	..	..	2.84	..	..	
	8	..	..	2.22	..	..	..	..	..	2.98	..	..	
	9	..	..	2.47	..	..	..	..	..	..	..	..	
	10	..	..	2.88	..	..	..	..	..	..	..	..	
	11	..	2.25	..	..	2.21	..	..	..	2.48	..	..	
	12	..	2.54	..	..	..	2.66	..	..	3.55	..	..	
	13	..	..	2.26	..	2.20	..	..	..	..	2.70	..	
	14	..	..	2.22	..	2.18	..	..	..	..	..	..	
	15	..	2.50	..	..	..	..	..	..	..	..	..	
	16	..	..	2.09	..	..	..	..	..	..	..	..	
	17	..	..	..	..	..	2.46	..	..	..	..	..	
1954	18	1.85	..	2.84	..	..	..	..	..	3.31	..	..	
	21	..	2.83	..	..	..	..	..	..	..	2.69	..	
	22	1.95	2.22	..	..	..	..	..	..	2.90	..	..	

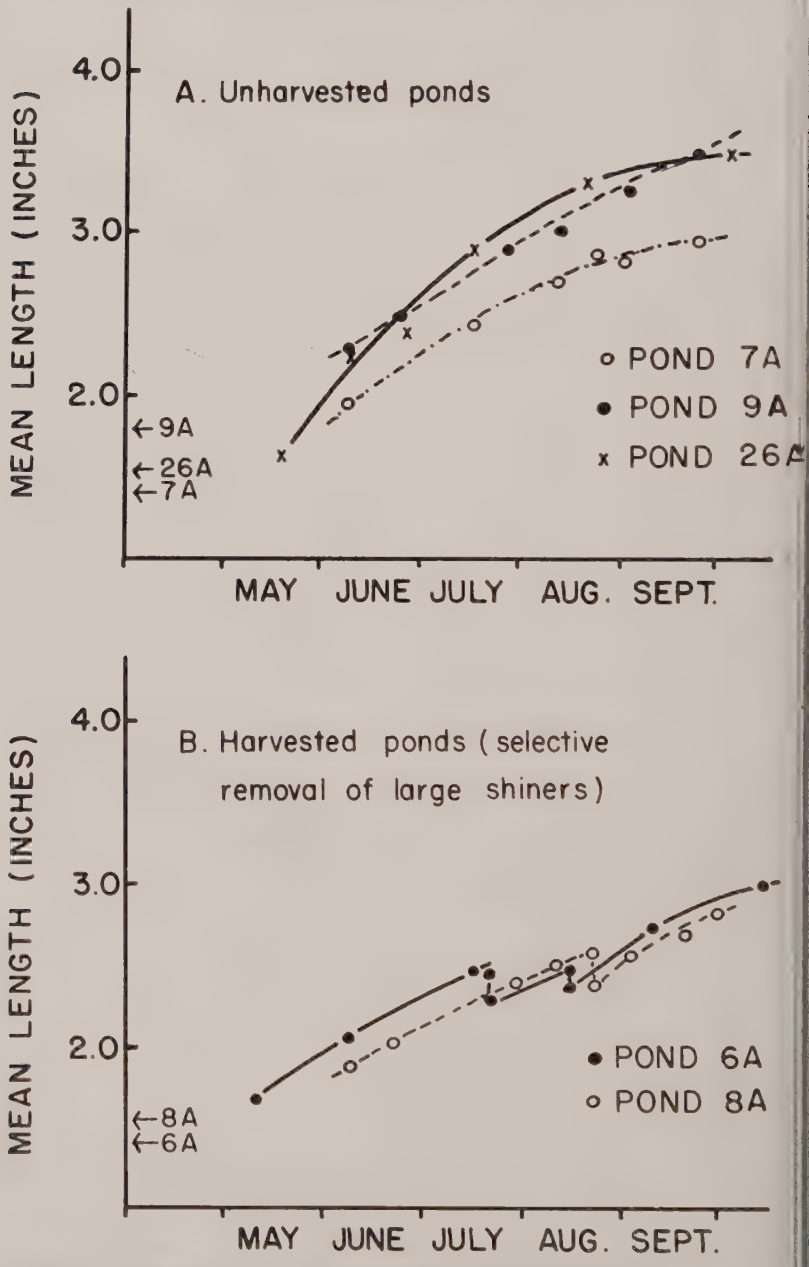


Figure 3. Growth in length during 1955 of yearling golden shiners in tw categories of fertilized ponds stocked in October 1954: A, unha vested; B, harvested. Arrows indicate mean lengths at stockin

Table 8. Mean Length of Golden Shiners* at the Beginning and End of Their Second Growing Season

Pond	At stocking (spring 1954)		At inventory (fall 1954)	
	Number per acre	Mean length (inches)	Mean length (inches)	Length increment
7	86,000	1.86	2.85	0.99
6	72,200	1.94	2.84	0.90
25	22,600	2.28	3.22	0.94
26	20,700	2.28	3.40	1.12
27	12,000	2.20	3.13	0.93
28	9,100	2.26	3.59	1.33

* Yearlings stocked at various rates at the start of the second growing season.

Spring plantings of yearling golden shiners were made in Ponds 25, 26, 27 and 28, and these were inventoried the following fall. Representative samples of yearlings were also obtained in two ponds (6 and 7) which were managed for a 2-year period. Despite differences in population density, length increments of yearlings were similar (Table 8). Expected correlation between growth and density may have been obscured by differences in pond fertility and the variation in mean lengths of stock placed in these ponds.

Effect of Fertilization on Growth The mean lengths of yearling golden shiners in unfertilized ponds (1, 2 and 3) and in fertilized ponds (5, 6, 7, 8, 11, 12, 13, 21, 22 and 29) were similar at the end of the second growing season (Table 7). The absence of significant differences in growth was verified by analysis of variance using samples collected in August and September. The average number of yearlings per acre in unfertilized ponds was 13,730 compared with 48,020 in fertilized ponds. Lower population density in unfertilized ponds apparently compensated for their lower food production.

Standing Crop and Yield

The standing crop in ponds stocked with adults was usually estimated at the end of the first and second growing seasons. The number and weight of golden shiners removed between inventory periods, when added to the standing crop at the end of the season, are reported as the yield.

Fertilized Ponds The standing crop of golden shiners in 12 fertilized ponds at the end of one growing season is shown in Table 9.

Table 9. Standing Crop of Golden Shiners at the End of First Gro ing Season in Fertilized Ponds Initially Stocked wi Adults

Pond	Adults stocked per acre	Standing crop per acre				Fertilizer	
		Pounds*	Numbers in inch size classes			Pounds per acre	Typ
			1–2*	2–3	3–4		
5	200	180	4,400	38,800	..	400 3,800	6–12– manu
6	960	191	1,540	42,340	..	400 3,800	6–12– manu
7	620	198	43,500	15,060	4,160	740 1,000	6–12– manu
8	620	252	21,270	59,460	..	400 3,800	6–12– manu
9	220	170	2,170	16,020	10,280	720 1,000	6–12– manu
10	920	160	..	3,270	12,830	670 1,000	6–12– manu
11	1,320	54	3,100	6,310	..	350	6–12–
12	670	147	..	10,650	3,270	440	12–12–
13	1,000	145	10,500	21,900	5,000	400 1,300	6–12– manu
14	2,000	155	8,400	24,920	..	400 1,400	6–12– manu
18	250	220	..	20,790	8,910	1,870	6–12–
22	740	136	8,850	12,400	..	1,200	6–12–
Average.....		167	8,640	22,660	3,709	647 1,420	inorga manu

* Minimum estimate, as ¼-inch-mesh seines did not retain shiners less than 1.8 inches in length in proportion to abundance.

The weight of the standing crop in these ponds was estimated at to 252 pounds per acre with a class average of 167 pounds. The figures, based on seining with ¼-inch mesh, are reliable estimates the population over 1.8 inches in total length. An appreciable numb of young were less than 1.8 inches in length at the end of the fi growing season, but they represented less than 20 per cent of t population weight in two ponds. Standing crops in Ponds 6 and were estimated at 191 and 198 pounds per acre, respectively. Co

plete recovery of shiners after ponds were drained increased the weight of the standing crop by 31 pounds per acre in Pond 6, and by 40 pounds per acre in Pond 7.

The entire fall crops in 10 fertilized ponds stocked in 1953 and three fertilized ponds stocked in 1954 were overwintered for further growth during a second growing season. By late summer the standing crop averaged 362 pounds per acre (Table 10). When the golden shiners removed from these 10 ponds during the second growing season were added to the standing crop, the yield for the 2-year period averaged 420 pounds per acre.

TABLE 10. STANDING CROP OF GOLDEN SHINERS AT THE END OF TWO GROWING SEASONS IN FERTILIZED PONDS INITIALLY STOCKED WITH ADULTS, AND THE NUMBER AND WEIGHT HARVESTED DURING PRECEDING TWO GROWING SEASONS

Pond	Adults stocked per acre	Item	Yield per acre				Fertilizer*	
			Pounds	Numbers in inch size classes			Pounds per acre	Type
				1–2§	2–3	3–4		
5	200	Standing crop	332	..	15,200	18,000	1,490	6-12-6
		Harvest	316	..	16,880	14,000	3,800	manure
6	960	Standing crop†	515	..	37,340	21,180	1,450 3,800	6–12–6 manure
7	620	Standing crop†	474	..	26,210	29,120	1,830	6-12-6
		Harvest	189	..	23,650	8,330	1,000	manure
8	620	Standing crop†	529	..	24,900	27,520	1,530	6–12–6
		Harvest	76	..	5,840	2,920	3,800	manure
11	1,320	Standing crop	136	2,400	8,170	8,170	870	6–12–6
12	670	Standing crop	247	..	5,170	13,340	1,040	12–12–12
13	1,000	Standing crop†	465	..	34,200	13,600	1,740	6–12–6
21	500	Standing crop†	121	..	..	8,440	2,160	8–8–4
22	740	Standing crop	261	8,380	29,620	3,780	1,800	6–12–12
29	200	Standing crop	540	..	29,800	27,200	2,500	6–12–6
Means.....		Standing crop	362	1,080	21,060	17,040	xxx	xxx
		Harvest	58	..	4,640	2,520	xxx	xxx
		Total Yield	420	1,080	25,700	19,560	xxx	xxx

* For 2-year period.
§ Minimum estimate, as ¼-inch-mesh seines did not retain shiners less than 1.8 inches in length in proportion to abundance.
† Pond drained.

Fertilized ponds which were turbid with suspended clay (Secc disc transparency 14-24 inches) produced low standing crops shiners. The mean in turbid ponds (11 and 22) at the end of t first growing season was 95 pounds per acre compared with 182 pour per acre in other ponds shown in Table 9. The average yield a 2-year period from three turbid ponds (11, 21 and 22) was 1 pounds per acre, while ponds not turbid with suspended clay yield nearly three times this weight.

Unfertilized Ponds One pond stocked with golden shin in 1951, and three ponds (1, 2 and 3) stocked in the spring of 19 were not fertilized. The standing crops in these ponds at the end the 1954 growing season ranged from 79 to 145 pounds per a (Table 11). The only removal of minnows was 18 pounds per a from Pond 4 in 1953, and this probably did not appreciably aff the size of the standing crop at the 1954 inventory.

Table 11. Standing Crop of Golden Shiners in Four Unfertili Ponds at the End of the 1954 Growing Season

Pond	Year stocked	Number stocked per acre	Standing crop per acre				
			Pounds*	Numbers in inch size classes			
				1–2*	2–3	3–4	4–
1	1953	1,880	100	..	24,000	..	.
2	1953	560	104	5,610	7,980	3,440	.
3	1953	750	79	1,000	1,100	5,800	.
4	1951	unknown	145	..	5,790	5,790	67

* A minimum estimate, as ¼-inch-mesh seines did not retain shiners than 1.8 inches in length in proportion to their abundance.

Weight of the mean standing crop in the four unfertilized por was only one-fourth as large as in fertilized ponds at the end of t second growing season.

Rearing Ponds Four ponds were stocked with 2.0- to 2.5-in yearling golden shiners in the spring of 1954. All reached a leng of over 3 inches by fall (Table 12) and most were bass-size by l summer. Approximately 1,000 yearlings attained pike-size in Po 28. However, the monetary value of the bait in Pond 28 was less th that in Ponds 25 and 26 where, at higher stocking rates, yearli grew to bass-size. Present information suggests it is not commercia feasible to rear golden shiners to a size suitable for pike bait in fertili ponds.

TABLE 12. STANDING CROP IN FALL IN PONDS STOCKED WITH YEARLING GOLDEN SHINERS IN THE SPRING OF 1954

Pond	Yearlings stocked per acre	Standing crop per acre					Fertilizer	
		Pounds	Numbers in inch size classes				Pounds per acre	Type
			1–2	2–3	3–4	4–5		
25	22,600	306	44,120	5,680	20,500	..	1,200	6–12–6
26	20,700	360	50,600	25,400	16,000	..	1,300	6–12–6
27	12,000	127	..	..	10,900	..	170 330	5–10–5 soybean meal
28	9,100	267*	4,200*	4,600	7,000	1,000	..	..

* Minimum estimate, as ¼-inch-mesh seines did not retain shiners less than 1.8 inches in length in proportion to their abundance.

The 2.0- to 2.5-inch yearlings stocked in Ponds 25, 26 and 28 matured and spawned during the summer. The presence of young shiners interfered with the harvesting of bait and probably reduced the growth of stocked yearlings. Golden shiners over 2 inches long at the end of their first growing season generally spawn during the second year, but smaller individuals may not mature until their third growing season. The stocking of 1- to 2-inch young in the fall was tested as a method of producing bass-size bait and reducing the abundance of young.

Young ranging in mean length from 1.4 to 1.8 inches were stocked in four fertilized rearing ponds during October 1954. Yearlings were

TABLE 13. STANDING CROP OF GOLDEN SHINERS IN THE FALL OF 1955 AND THE NUMBER AND WEIGHT HARVESTED FROM PONDS STOCKED WITH YOUNG IN OCTOBER 1954

Pond	Young stocked per acre		Yield per acre				Fertilizer	
	Pounds	Number	Item	Pounds	Number in inch size classes		Pounds per acre	Type
					2–3	3–4		
5A	46	42,350	Standing crop Harvest	127 114	7,370 16,280	6,300 650	1,040	0–12–0
7A	50	46,000	Standing crop	312	16,590	14,220	1,120	0–12–0
8A	40	35,650	Standing crop Harvest	134 87	10,800 9,130	4,460 1,580	940	12–12–6
9A	48	28,710	Standing crop	296	..	19,190	1,090	12–12–6

harvested from two of these in the following July and August, a all ponds were inventoried in the period September-October 19 (Table 13). Golden shiner fry were observed in all ponds dur late August. These young were less than 1 inch long when the po were inventoried and did not interfere with the harvest of yearlin

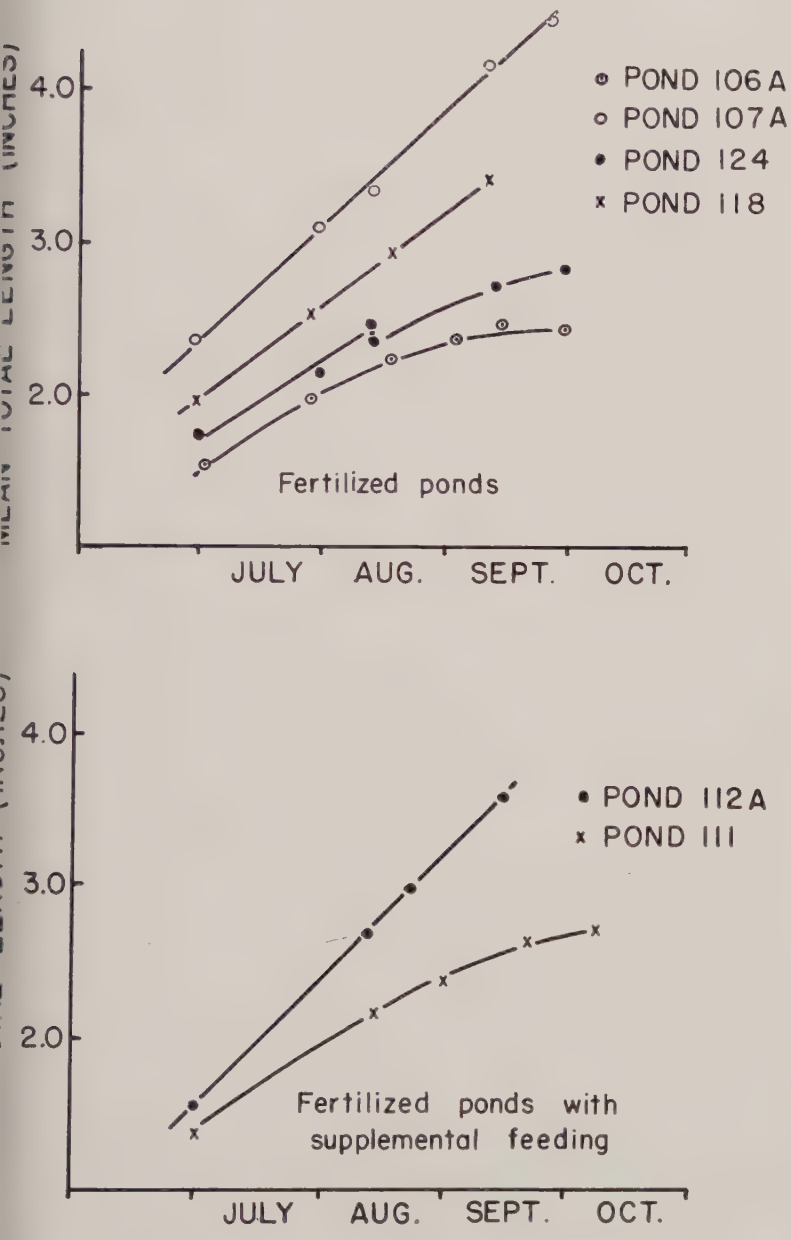
In Pond 9A, stocked at the lowest rate (28,710 per acre), yearling shiners were bass-size by fall, but few yearlings in any of ponds had reached bass-size by midsummer (mean lengths shown Figure 4). Stocking of fertilized rearing ponds with young averag 1.4 to 1.8 inches long in the fall is not a practical means of produc summer bass-size bait.

However, production of bass bait can be increased by supp mental feeding.

Supplemental Feeding Golden shiners in Pond 26A were soybean meal at a rate of 20 pounds per acre per day between June and September 29, 1955. Daily applications of dry meal were bro cast from shore. This pond was stocked in October 1954 with 67,0 shiners (1 to 2 inches long) per acre weighing 87 pounds. Wh drained the following October, 53,470 shiners 3 to 4 inches long a weighing 765 pounds were recovered. Fertilized ponds stocked w young in October yielded 221 to 312 pounds per acre by the fall 1955 (Table 13). The much higher yield in Pond 26A is apparen attributable to the feeding of about 2,000 pounds of soybean meal acre.

Effect of Harvesting on Total Yield Different prop tions of yearlings were harvested from four adjacent golden shi ponds in the summer of 1954. Estimated populations at the e of the 1953 growing season ranged from 180 to 252 pounds per a (Table 9). All four ponds were inventoried later in the same ye at which time standing crops were determined. The data t obtained on harvest and yield are presented in Table 14 (Ponds 6, 7 and 8). The positive relationship between weight harvested a weight of yield in these ponds suggests that total yield of yearl shiners was increased by harvesting.

After being drained in August-September 1954, three of the ab ponds (designated as 6A, 7A and 8A) and a fourth adjacent po (9A) were each stocked with 46 to 50 pounds of young shiners acre in October 1954 (Table 13). The standing crop of yearlings the spring of 1955 was probably slightly lower as a result of natu mortality over winter. Two ponds (6A and 8A) were harvested



gure 4. Growth in length of suckers during their first summer of life (1955).

Table 14. Harvest and Yield of Yearling Golden Shiners fr Adjacent Fertilized Ponds

High initial standing crop			Low initial standing crop		
Pond	Pounds per acre		Pond	Pounds per acre	
	Harvest	Yield		Harvest	Yield
6	..	515	7A	..	312
8	76	605	9A	..	296
7	189	663	8A	87	221
5	316	648	6A	114	241

July and August and population estimates were made in all po in September-October 1955. The yield in the harvested po averaged 231 pounds per acre compared with 304 in the unharves ponds (Table 14).

The removal of golden shiners increased the yield in 1954 w the standing crop was relatively large but decreased it in 1955 w the standing crop was lower. Although the differences in yield co have been due either to dissimilar environmental conditions in ponds or to the method of management, the latter is considered m probable as these adjacent ponds were similar in size, morphome and history of fertilization.

The 1955 data suggest that removal of golden shiners when standing crop is under 50 per cent of the carrying capacity (judg from Ponds 6 and 7 in 1950 the carrying capacity was over 500 pou per acre) may reduce the weight yield. But, the bait propagato generally interested in producing the maximum number of 3-i golden shiners. The maximum number of 3-inch shiners will obtained by removing the fish as soon as they reach this size regard of the effect such removals have on the weight production, si removal of bait may increase growth and must reduce losses fr natural mortality.

WHITE SUCKER

The white sucker has been reared in northern states to meet demand for large bait fish used in angling for northern pike a muskalonge. Suckers 3 to 4 inches in length are an acceptable sum bass-size bait, but smaller suckers are seldom marketed by New Y bait dealers. Survival, growth, and yield of suckers is based on inf mation obtained from 3 ponds stocked with eyed eggs, 20 po stocked with fry, and 2 ponds stocked with yearlings.

SURVIVAL

Ponds stocked with free-swimming sucker fry in May were usually inventoried during the following September and October. All ponds were fertilized 2 to 3 weeks prior to stocking and additional fertilizer was applied at intervals during the summer. Suckers harvested from ponds during late summer were added to the estimated number present in the fall in determining survival. No correction was made for natural mortality of harvested suckers which would have occurred between the time of harvest and fall inventory 4 to 6 weeks later. Because the number of suckers harvested was generally less than one-third the fall standing crop, survival comparisons between harvested and unharvested ponds are probably valid.

SURVIVAL OF FRY TO FALL Fry survival in the 18 ponds ranged from 1.7 to 71.2 per cent (Table 15). These ponds were stocked at rates of 50,000 to 231,000 fry per acre. The coefficient of correlation

TABLE 15. NUMBER OF SUCKERS RECOVERED IN THE FALL FROM FERTILIZED PONDS STOCKED WITH FRY

Pre-stocking treatment	Pond	Number stocked per acre	Number recovered per acre*	Per cent survival
None	104	70,000	6,940	9.9
	108	100,000	1,750	1.7
	103	100,000	13,500	13.5
	101	110,000	6,700	6.1
	115	110,000	20,010	18.2
	113	166,000	47,840	28.8
	106	200,000	11,020	5.5
	116	230,000	55,210	24.0
	105A	231,000	22,830	9.9
	Mean			13.1
Sprayed with kerosene	107A	60,000	10,460	17.4
	108A	75,000	17,800	23.7
	122	80,000	27,800	34.8
	123	100,000	27,150	27.1
	124	150,000	55,180	36.8
	106A	200,000	72,960	36.5
	Mean			29.4
Drained before stocking	112	50,000	21,510	43.0
	112A	100,000	33,270	33.3
	111	160,000	113,910	71.2
	Mean			49.2

* During August-October period.

between number of fry stocked and number of fall fingerlings remo was 0.01, suggesting that little if any of the variation in survival associated with stocking rate.

The mean survival of 24 per cent in New York ponds compa favorably with 21 per cent survival in Minnesota ponds stocked w fry (Dobie *et al.*, 1956). Although the effect of high mortality reducing the yield of bait fish might be corrected by increasing stocking rate, great variation in survival seriously hampers mana ment of sucker ponds. It is desirable, therefore, to determine factors limiting survival.

Factors Limiting Survival Mortality of young is gener believed to be substantially higher during the first few weeks of life t at any subsequent time. Early fry mortality in bait ponds is of attributed to inadequate plankton food or to predation by aqua insects. Although zooplankton is utilized by young suckers (Bigel 1923), the plankton concentration necessary to assure fry survi has not been studied.

Tests were conducted in concrete tanks at the Cornell Exp mental Fish Hatchery to evaluate the effect of low plankton den on early fry survival. Five tanks with surface areas of 96 square f were each stocked with 100 advanced fry (45,000 per acre) on Ju 20, 1954. Three of the tanks were filled with water and each v fertilized with ¼ pound of soybean meal on June 1. By June 20 seston concentrations in these tanks averaged 5.8 milligrams per l in contrast to 0.1 milligram per liter for the remaining tanks (2 and which were filled with water from Cascadilla Creek immediately bef

Table 16. Fry Survival and Seston Concentrations in Five Concr Tanks Each Stocked with 100 Sucker Fry on June 20 Inventoried 20 Days Later on July 9, 1954

Tank	Total seston concentration*			Sucker fry on July 9	
	June 20	June 27	July 9	Per cent survival	Mean tota length§
1	6.0	5.8	6.7	72	24.6
2	0.1	2.9	5.2	80	24.4
3	4.9	5.9	6.2	79	27.8
4	0.1	1.1	3.4	70	23.5
5	6.4	7.6	7.6	75	25.0
Mean....	3.5	4.7	5.8	75	25.1

* In milligrams per liter.
§ In millimeters.

ocking (Table 16). Plankton samples taken with a No. 20 silk net dicated a high population of rotifers and entomostraca in Tanks 3 and 5, and confirmed the near absence of plankton in Tanks and 4.

Between 70 and 80 per cent of the fry stocked in all tanks survived the end of the 20-day test period. There was no consistent differ-ice in survival between tanks with high and low initial seston con-ntrations. Since the average concentration in all tanks was less than e minimum found in most fertilized ponds, it appears unlikely that arvation is a source of fry mortality during their first two weeks in onds.

Aquatic insects are important fry predators in Minnesota bait onds (Dobie, 1948). To assess the extent of insect predation in ew York ponds, three ponds were drained and refilled a week before ocking. Drainage of these ponds eliminated nearly all aquatic insects. erosene, applied to the surface of six other ponds, killed most otonectids, dytiscids and other air-breathing aquatic insects. Mean rvival of fry to fall in drained and refilled ponds was 49.2 per cent mpared with 29.4 per cent in ponds treated with kerosene. Survival nine untreated ponds averaged 13.1 per cent (Table 15). The cor-lation between survival and the apparent effectiveness of insect ntrol suggests that insect predation is an important source of fry ortality.

Survival Over Winter Suckers not of desirable bait size by l were held over winter in eight ponds and reared to salable size ring the following spring. Fall and spring populations were deter-ned by drainage of the ponds or estimated by repeated seining.

BLE 17. Survival of Young Suckers from Fall to Spring Inventory in Bait Ponds (1954-1955)

Pond	Number per acre		Per cent survival
	September-October	May-June	
111	95,640	74,400	77.8
112	14,670	7,610	51.9
112A	11,900	9,350	78.6
113	37,860	32,990	87.1
114	32,500	24,360	74.9
116	18,400	17,290	94.0
120	5,050	4,700	93.0
125	18,500	15,000	81.1
an			79.8

The percentage survival in eight ponds from September-October 1954 to May-June 1955 is shown in Table 17. Although the population estimates for these ponds were not equally precise, the mean survival of 79.8 per cent is probably representative of the survival which can be expected in overwintering young suckers.

Growth

Growth data are based on the observed mean lengths of samples of 15 to 75 suckers collected between July and October of the first growing season, and between April and June of the second growing season following stocking. Collections of young in July and early August were made with a 20-foot ⅛-inch-mesh seine. After mid-August, ¼-inch-mesh seines were employed.

Length of Growing Season Three ponds, stocked in the spring of 1954, were sampled monthly in the fall (1954) and spring (1955) to provide information on length of the growing season. In these ponds young suckers grew at a fairly rapid rate into October (Table 18). The increment in mean length between late October

Table 18. Growth of Suckers in Three Bait Ponds during Fall and Spring Months (1954-55) Following Stocking in Spring of 1954

Pond	Mean total length (inches)*					
	August	September	October	April	May	June
113	1.77 (0.06)	2.40 (0.05)	2.64 (0.05)	2.69 (0.05)	2.84 (0.09)	....
114	2.02 (0.06)	2.19 (0.06)	2.57 (0.08)	2.60 (0.08)	2.80 (0.08)	....
120	....	2.86 (0.05)	3.48 (0.06)	3.49 (0.05)	3.64 (0.05)	5.53 (0.11)

* Standard deviations of means in parentheses.

and early April in each pond was less than one standard deviation of the mean, indicating that little or no growth occurred between these sampling periods. Growth was resumed in April.

Growth Rate Four adjacent ponds were stocked in the spring of 1955 and all were fertilized at similar rates during the following summer. Mean lengths of suckers collected from these ponds are plotted against time in Figure 4. Growth between July and September

was nearly linear in Ponds 107A and 108A, with fall standing crops of 10,460 and 17,800 suckers per acre, respectively. Growth tended to decrease during late summer in Ponds 106A and 124, where fall standing crops were 54,200 and 42,900 suckers per acre, respectively. The removal of 12,200 of the larger suckers from Pond 124 in August, and the nonselective removal of 18,760 suckers from Pond 106A, did not appear to increase the growth rate of the remaining suckers in either pond.

Growth rate of suckers in two ponds receiving supplemental food is also shown in Figure 4. The plot of mean length against time was nearly linear for Pond 112A with a population density of 33,270 suckers per acre. Growth rate appeared to decrease in late summer in Pond 111 where the fall population density was 117,820.

Suckers stocked as eyed eggs or fry in 19 ponds ranged in mean length from 2.19 to 5.60 inches by fall (Table 19). Growth rate was inversely correlated with fall population density (Figure 5). This relationship between mean length and fall population density is satisfactorily described by the equation:

$$\log L = 2.1272 - 0.3762 \log P$$

In this equation L represents the mean total length in inches and P, the population density per acre.

TABLE 19. MEAN OBSERVED LENGTH OF SUCKERS IN 19 FERTILIZED PONDS AT INTERVALS DURING FIRST GROWING SEASON

Pond	Mean total length (inches)		
	August	September	October
101	....	....	5.54
103	....	2.82	3.43
104	....	....	4.50
105A	2.69	....	2.71
106	3.75	4.20	....
106A	....	2.35	....
108	4.60	5.60	....
107A	....	4.45	....
109	4.18	....	5.62
108A	....	3.42	....
112	2.33	....	3.07
113	1.77	2.40	2.64
114	2.02	2.19	2.57
115	2.68	....	3.23
116	2.14	2.62	....
118	....	2.58	....
122	....	2.90	....
123	1.85	2.54	2.89
124	2.46	2.70	....

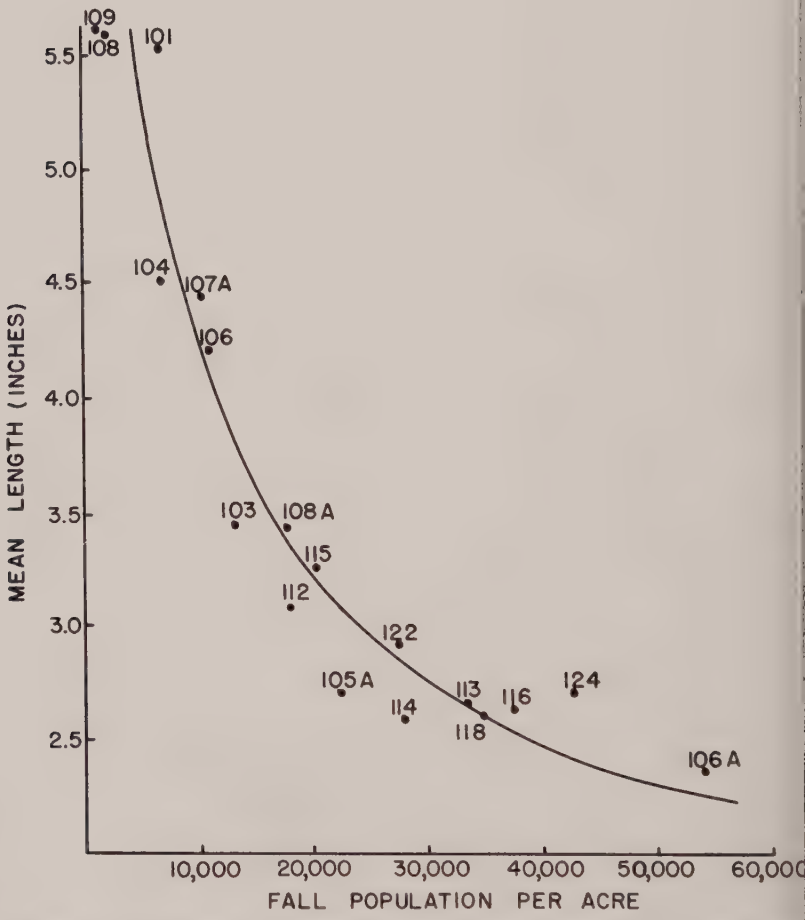


Figure 5. Relationship of mean length of young suckers to fall populatio density in fertilized ponds.

Ponds 108 and 109 were excluded in computing the above regres sion since the fall mean length was approximately 3 inches less tha expected from the above equation. Possibly at the low populatio densities of 1,750 and 1,220 per acre which characterized these ponds population density does not limit growth of young suckers. How ever, in most of the fertilized ponds mean length could have bee predicted rather precisely from the fall population density, using th graph in Figure 5.

Growth between fall and spring will determine the feasibility o rearing fall fingerling suckers to meet the spring demand for pik

TABLE 20. LENGTH INCREMENT BETWEEN FALL AND SPRING AND THE SPRING POPULATION DENSITY IN BAIT PONDS WHERE FALL FINGERLING SUCKERS WERE OVERWINTERED

Pond	Mean total length (inches)		Mean length increment (inches)	Spring population (number per acre)
	September-October	May		
120	2.86	3.64	0.78	4,700
112	2.76	3.52	0.76	7,610
105	3.72	4.62	0.90	8,830
102	3.16	4.34	1.18	13,530
116	2.45	2.83	0.38	17,290
114	2.19	2.80	0.61	24,360
113	2.40	2.84	0.44	32,990
Mean....	2.79	3.51	0.72	15,616

ize bait. The length increment between September and May in seven ertilized ponds averaged 0.72 inch (Table 20). The length increment exceeded 0.75 inch in ponds with under 14,000 suckers per cre and was less than 0.61 inch in ponds with populations over 7,000 suckers per acre.

TANDING CROP AND YIELD

Standing crops were estimated in September or October, 5 to 6 ionths after stocking. In several ponds young suckers were over-intered and a second population estimate was made in May.

PONDS STOCKED WITH FRY OR EGGS The standing crop of ickers in 19 ponds inventoried in the fall amounted to 87 to 410 ounds per acre 5 to 6 months after stocking, with an average of 47 pounds per acre (Table 21). The average yield was 285 pounds er acre. Differences in standing crop and yield between individual onds did not appear related to the type or quantity of fertilizer pplied. Nor did the population density have a noticeable effect on ie weight of the fall standing crop (correlation coefficient = 0.29, .f. = 17).

Clay turbidity may have contributed to the relatively low standig crops in Ponds 105A, 108, 109, 112, 118 and 123. The mean yield i these ponds was 174 pounds per acre compared with 336 pounds per cre in the remaining 13 ponds listed in Table 21.

The average yield per acre from 19 ponds listed in Table 21 onsisted of 17,280 suckers 2 to 3 inches long, 5,240 suckers 3 to 4 ches long, and 2,210 suckers over 4 inches long. In ponds with fall

Table 21. Standing Crop of Suckers at the End of the First Growi Season in Fertilized Ponds, and the Number and Weig Harvested during Late Summer

Pond	Stocking rate per acre	Yield per acre						Fertilizer	
		Item	Pounds	Numbers in inch size classes				Pounds per acre	Type
				1-2	2-3	3-4	4-6		
101*	110,000 fry	Standing crop	410	..	..	..	6,700	270	5-10-
								400	soybe meal
103	100,000 fry	Standing crop	270	..	2,100	11,400	..	1,600	5-10-
								4,500	manu
104*	70,000 fry	Standing crop	252	..	..	410	6,530	800	5-10
								600	manu
105A	231,000 fry	Standing crop	169	..	19,180	3,650	..	2,300	5-10-
106*	200,000 fry	Standing crop	388	..	..	..	11,020	1,300	10-10-
106A	200,000 fry	Standing crop	290	..	53,600	..	600	1,000	5-10-
		Harvest	102	5,040	11,560	2,160	..		
107A	60,000 fry	Standing crop	307	..	..	2,250	8,210	1,160	5-10-
108*	100,000 fry	Standing crop	87	..	..	100	1,650	1,570	10-10-
108A	75,000 fry	Standing crop	286	..	2,990	12,490	2,320	1,120	5-10-
109*	375,000 eyed eggs	Standing crop	111	..	..	..	1,220	2,200	5-10-
112*	50,000 fry	Standing crop	171	..	11,330	6,680	370	1,400	6-12-
		Harvest	53	..	..	2,070	1,060		
113	166,000 fry	Standing crop	214	..	33,700	..	..	1,800	5-10-
		Harvest	100	7,400	6,740	..	..		
114	400,000 eyed eggs	Standing crop	155	6,910	20,200	1,820	..	1,800	5-10
		Harvest	43	..	3,740	1,600	..		
115	110,000 fry	Standing crop	226	..	6,450	13,560	..	1,800	5-10-
116	230,000 fry	Standing crop	329	..	25,820	11,650	..	2,100	5-10-
		Harvest	118	..	17,740	..	..		
118*	57,000 eyed eggs	Standing crop	244	..	33,180	1,040	700	1,400	6-12-
								700	manu
122*	80,000 fry	Standing crop	310	..	15,400	11,600	800	1,200	6-12-
123	100,000 fry	Standing crop	100	..	6,670	3,800	..	300	5-10-
		Harvest	108	..	16,680	..	..	6,700	manu
124	150,000 fry	Standing crop	375	..	33,850	8,450	680	1,120	5-10-
		Harvest	200	..	7,450	4,750	..		
Means.....		Standing crop	247	360	13,920	4,680	2,150	xxx	xxx
		Harvest	38	660	3,360	560	60	xxx	xxx
		Total yield	285	1,020	17,280	5,240	2,210	xxx	xxx

* Pond drained.

population densities under 12,000 suckers per acre, most young sucke were over 4 inches in length by fall. At population densities ov 30,000 per acre, less than 20 per cent of the suckers reached a leng of 3 inches. Although small suckers can be overwintered for furth growth, only a limited number of these can be reared to a length 3 inches by May when ponds are usually restocked with fry.

Young suckers in seven fertilized ponds were overwintered a

population estimate was conducted in the spring. The weight of ie standing crop in these ponds increased by an average of 92 pounds er acre between the fall and spring inventories (Table 22). In

ABLE 22. NUMBER AND WEIGHT OF SUCKERS IN THE FALL AND SPRING IN FERTILIZED PONDS WHERE YOUNG SUCKERS WERE HELD OVER WINTER (1954-55)

Pond	Fall standing crop per acre (September—October)					Spring standing crop per acre (May—June)			
	Pounds	Numbers in inch size classes				Pounds	Numbers in inch size classes		
		1–2	2–3	3–4	4–6		2–3	3–4	4–6
112	112§	..	11,330	3,340	..	110§	..	5,610	2,000
113	214	..	37,860	..	..	344§	23,720	7,910	1,360
114	155	6,910	23,770	1,820	..	214§	18,270	4,910	1,180
116	109	..	18,400	..	..	236	14,190	2,280	820
120	27§	..	3,590	1,460	..	160	..	..	4,700
102*	244	..	6,560	10,290	..	408§	..	1,610	11,870
105*	230	..	..	7,400	3,670	267	..	2,620	6,230
ean	156	990	14,500	3,470	520	248	8,020	3,560	4,020

* Total numbers of fall standing crop computed from spring population estimate, using a mean expected survival of 80 per cent between fall and spring. Total weight, and length distribution of fall standing crop, computed from mean weight and length-frequency distributions, respectively, in samples collected from these ponds in fall.
§ Pond drained.

ree ponds (113, 114 and 116), where 18,400 to 37,860 suckers 2 to inches long were overwintered, only 25 per cent of the survivors were er 3 inches in length by spring. In the remaining four ponds, all conining under 17,000 suckers (2 to 4 inches long) per acre in the ll, the entire spring standing crop was composed of suckers over inches in length. It is difficult to generalize from these results as e proportion of suckers reaching a salable size of 3 inches by spring determined by both the mean length and the density of the fall opulation. However, it does not seem advisable to overwinter more an 15,000 suckers (2 to 3 inches long) per acre if they are to be ared to bass- and pike-size by May.

PONDS STOCKED WITH YEARLINGS Ponds 107 and 121 were ocked with 2- to 3-inch yearling suckers in May. When these arlings were removed in the following August and September, all d reached bass- and pike-bait size (Table 23). In both ponds a rge proportion of the crop reached bass-size in July. Stocking small

Table 23. Yields of Suckers in 5 Months from Two Fertilized Pon Stocked with 2- to 3-inch Yearlings in May

Pond	Yearlings stocked per acre	Yield per acre			Fertilizer	
		Pounds	Numbers in inch size classes		Pounds per acre	Type
			3–4	4–6		
107*	12,470	479	4,515	7,030	2,200	5–10–5
121*	24,640	424	10,820	7,320	950 3,000	5–10–5 manur

* Pond drained.

yearling suckers in the spring will enable the bait producer to harv bass- and pike-size bait by July, but it is doubtful if this method managing ponds has any financial advantage over the stocking of f

Supplemental Feeding Suckers stocked in Pond 111 w fed soybean meal in 1954 at a rate of 8 pounds per acre per day July, 12 pounds in August, and 20 pounds in September. Suckers Pond 112A were fed soybean meal at the same rates in 1955. Da applications were made by broadcasting dry meal into shallow wa along one side of the pond.

Pond 111 produced 880 pounds of suckers per acre in a 6-mon period with supplemental feeding (Table 24). The maximum yi attained in any fertilized pond without supplemental feeding was 5 pounds per acre (Table 21). Feeding 1,200 pounds of soybean m in Pond 111 appears to have increased the per-acre yield at least 3

Table 24. Standing Crop of Suckers at the End of the First Growi Season in Fertilized Ponds which Received Supplement Feed

Pond	Standing crop per acre				Fertilizer		Soybea meal* (pound per acr
	Pounds	Numbers in inch size classes			Pounds per acre	Type	
		2–3	3–4	4–5			
111§	880	104,700	13,120	...	600	6–12–6	1,200
112A§	553	4,000	20,610	8,660	200 2,000	6–12–6 manure	1,200

* Fed at a rate of 8 pounds per acre per day in July, 12 pounds in Augu and 20 pounds in September.
§ Pond drained.

unds. This would suggest a food conversion ratio of 1:4 or lower. nd 112 yielded 224 pounds of suckers per acre in 1954 with fertiliza- n, compared with 553 pounds per acre in 1955 with fertilization d supplemental feeding. If the entire 329-pound difference in yield attributed to feeding 1,200 pounds of soybean meal per acre the od conversion ratio was 1:3.6.

ABLE 25. NUMBER AND WEIGHT OF SUCKERS STOCKED IN OCTOBER AND STANDING CROP IN MAY IN PONDS RECEIVING SUPPLEMENTAL FEED

Pond	Item	Data per acre				Soybean meal* (pounds per acre)
		Pounds	Numbers in inch size classes			
			2–3	3–4	4–6	
11§	Number stocked in fall	600	95,640	..	..	..
	Standing crop in spring	960	70,400	4,000	..	1,000
12A§	Number stocked in fall	90	11,900	..	..	..
	Standing crop in spring	202	..	5,300	4,050	700
25§	Number stocked in fall	132	16,500	2,000	..	..
	Standing crop in spring	343	..	8,540	6,460	700

* Fed at a rate of 15 to 20 pounds per acre per day from April 1 to late May.
§ Pond drained.

Young suckers held over winter in three ponds were fed soybean al at a rate of 15 to 20 pounds per acre per day between April 1 d late May. The net weight gain between fall and spring inven- ies averaged 228 pounds per acre (Table 25). In seven comparable nds where fertilization but no supplemental feeding was done, the erage weight gain was 92 pounds per acre between fall and spring able 22).

FATHEAD MINNOW

Data on growth and yield of fathead minnows were obtained from ht ponds stocked with adults and two ponds stocked with yearlings. ven of the eight ponds were managed for 2 years and two for 3 years. thead minnows are salable in New York when they reach a length about 2 inches. Under conditions favorable for rapid growth, this cies can be reared to a length of 2.5 to 3.0 inches and sold as bass- bait. However, most New York ponds have produced few bass- individuals, and for the purposes of this study all minnows over inches long were classified as perch bait.

Reproduction

The fathead minnow deposits its eggs on the underside of rock boards, and plant leaves where they are tended by the male (Lor 1927; Markus, 1934). Spawning in New York ponds begins in M and continues throughout the summer. Eggs have been observed early as May 12 and as late as September 2.

Floating boards were attached at intervals along a wire stretch across each pond to supplement natural spawning sites. Althoug these boards were used to some extent in all ponds, flat rocks and su merged boards were preferred as nest sites.

Age at Maturing Samples of fathead minnors hatched three ponds (201, 202 and 203) were collected at the end of the fi growing season and in May and July of the second year. State sexual development was determined from the condition of the gona and from evidence of sexual dimorphism. There were no indicatio that young hatched early in the spring would spawn in the first ye of life as was found by Markus (1934) to occur in Iowa ponds. collections from Ponds 201 and 202 in May 1954 most yearling fema over 1.8 inches contained well developed eggs. Characteristic sexu demorphism was evident among some yearling males over 2.0 inch in length. Smaller yearlings, presumably those hatched late in t preceding summer, did not become mature until June or July of th second year. In Pond 203, where growth was slow, yearlings c not mature until July and some ripe females were only 1.5 inches lon

Post-spawning Mortality Several workers (Markus, 193 Prather *et al.*, 1953) have reported that a large proportion of matu fathead minnows die soon after spawning. The shorelines of tw ponds were searched weekly for dead minnows a year after stockin There was no evidence that the mortality of yearlings increas appreciably after they became sexually mature. Yearlings stock in two ponds (209 and 210) matured and spawned after stockin The mean survival of 92 per cent between June and September these ponds is additional evidence that post-spawning mortality d not constitute a problem in the management of this species in N York ponds.

Stocking Rate Fertilized ponds were stocked with 600 2,000 adult fathead minnows per acre. There was a tendency ponds stocked at low rates to yield larger numbers of salable-size you in the first year (see Table 27), which possibly can be attributed

e more rapid growth of young at low population densities. Since
e population estimates conducted in ponds did not include all min-
ows under 1.5 inches in length, it is not possible to establish a relation
etween stocking rate and the number of young produced.

Pond fertility and other environmental factors were probably more
nportant than stocking rate in determining the number produced
uring the second year in experimental ponds (see Table 28). There
as no indication that the yield in any of the ponds was limited by
adequate spawning.

ROWTH

Samples of fathead minnows were taken in late summer and fall
ith a ¼-inch-mesh seine. These samples were useful in estimating
e growth of young hatched early in the spawning season. Young
atched in July and August are seldom represented in such samples
proportion to their abundance.

In September of the first growing season the mean length of young
thead minnows seined from eight fertilized ponds ranged from 1.64
2.26 inches, with a class mean of 1.85 inches (Table 26). In three
these ponds a small proportion of the young were of salable size in
ugust of the first year.

The increment in mean length between September and April
eraged 0.02 inch in five ponds. Growth is apparently resumed in
ay and the mean length increment between April and June was 0.16
ch. The actual growth increment between sampling periods was
obably greater than indicated by the mean lengths shown, since
cruitment of yearlings into the "seinable" population was occurring.

BLE 26. MEAN TOTAL LENGTH OF YOUNG FATHEAD MINNOWS IN FALL AND THE FOLLOWING SPRING IN PONDS STOCKED WITH ADULTS THE PRECEDING SPRING

ond	Mean length in inches*					
	August	September	October	April	May	June
01	2.05	2.15	2.18	..	..	2.26
02	1.65	1.76	1.79	..	2.02	..
03	1.56	1.64	..	1.62	..	1.70
04	1.88	2.12	..	2.15	..	2.32
05	1.47	1.58	..	1.67	..	1.76
06	1.85	2.26	..	..	..	..
07	..	1.61	..	1.62	..	1.85
08	..	1.66	..	1.68	..	1.91

* Means based on samples of 30 to 50 specimens.

In two ponds where yearlings were stocked (see Table 30), the me length increment between June and September was 0.74 inch.

Standing Crop and Yield

The standing crop at the end of the first growing season in ei fertilized ponds stocked with adult fathead minnows ranged from to 209 pounds per acre with a mean of 96 pounds per acre (Table 2. Soybean meal was fed bi-weekly in two of the fertilized ponds (and 205) during the summer and fall. The average standing cr in these two ponds was 126 pounds per acre, compared with pounds per acre in the six ponds which received fertilizer alone. the end of the first growing season young were of salable size in se of the eight ponds under investigation.

Table 27. Standing Crop at the End of One Growing Season Fertilized Ponds Stocked with Adult Fathead Minnow

Pond	Adults stocked per acre	Standing crop per acre			Fertilizer*	
		Pounds§	Numbers under and over 1.8 inches long		Pounds per acre	Type
			Under	Over		
201	600	172	..	33,600	400	5-10 -
202	600	101	12,780	8,510	470	5-10-
203	1,000	35	10,500	..	1,200	6 12-
204	600	209	4,500	30,800	1,300	10-10-
205	2,000	80	23,400	2,600	2,000	manu
206†	2,000	62	..	13,120	1,500	5 10-
207	715	63	18,000	4,500	1,800	5-10 -
208	1,000	47	11,500	4,000	1,800	5 10-
Mean ..	.....	96	10,080	12,140	xxx	xxx

* In Ponds 201 and 205, supplemented by feeding 450 pounds and pounds of soybean meal, respectively.

§ Small minnows were inadequately sampled by the gear employed, so numbers under 1.8 inches long and total poundages are minimum estim

† Pond harvested in late summer; 108 pounds removed, consisting of 12 minnows under 1.8 inches and 6,580 over 1.8 inches in length.

All or most of the first year's hatches in seven ponds were h over winter and the fish removed during the second growing sea Weights and numbers harvested and the standing crops at the en the second year are shown in Table 28. The yield of salable-size over a 2-year period was approximately four times the standing c at the end of the first growing season. Fathead minnows under inches long were removed from three ponds (203, 207 and 208

ABLE 28. STANDING CROP OF FATHEAD MINNOWS AT THE END OF TWO GROWING SEASONS, AND THE NUMBER AND WEIGHT HARVESTED DURING THE 2-YEAR PERIOD FROM PONDS INITIALLY STOCKED WITH ADULTS

ond	Adults stocked per acre	Item	Yield per acre: Pounds†	Number under and over 1.8 inches long: Under†	Number under and over 1.8 inches long: Over	Fertilizer*§: Pounds per acre	Fertilizer*§: Type
01	600	Standing crop	120	19,000	9,500	450	5–10–5
		Harvest	329	..	52,700		
02	600	Standing crop	141	11,400	14,000	2,000	5–10–5
		Harvest	118	..	17,640		
03‡	1,000	Standing crop	66	28,500	..	3,700	6–12–6
		Harvest	130	41,000	6,000		
04	600	Standing crop	120	30,400	..	2,600	10–10–5
		Harvest	390	..	68,300		
06‡	2,000	Standing crop	118	..	30,740	2,460	5–10–10
		Harvest	458	62,500	47,310		
07‡	715	Standing crop	143	54,900	12,300	1,800	5–10–5
		Harvest	292	98,700	36,320	10,000	manure
08‡	1,000	Standing crop	219	58,400	11,000	6,000	manure
		Harvest	250	35,300	42,600	1,800	5–10–5
eans.....		Standing crop	132	28,940	11,080	xxx	xxx
		Harvest	281	33,930	38,700	xxx	xxx

* For 2-year period.
§ In Ponds 201 and 206, supplemented by feeding 1,350 pounds and 40 pounds of soybean meal, respectively.
† Minimum estimate of the standing crop since the gear employed in making population estimates did not retain fathead minnows under 1.8 inches in length in proportion to their abundance.
‡ Pond drained.

rease the growth of the remaining minnows. Numerous small indi-luals were removed and marketed from Pond 206 although they re not of a desirable bait size.

Ponds 201 and 202 were managed for three consecutive years hout draining or restocking. The numbers and weights of salable-minnows removed during the 3-year period are shown in Table Approximately the same numbers were removed from Pond 201 the second and third years. The increased yield during the third r in Pond 202 is attributed to the feeding of soybean meal in lition to regular fertilization.

Yearling fathead minnows ranging in total length from 1.1 to

Table 29. Number and Weight of Fathead Minnows Removed duri Three Successive Years from Two Ponds Stocked wi Adults in the Spring of 1953

Pond	Year	Quantity removed per acre		Fertilizer		Soybea meal (pound per acr
		Pounds	Numbers	Pounds per acre	Type	
201	1953	..	..	400	5–10–5	450
	1954	329	52,700	..	..	900
	1955	309	55,700	..	..	900
202	1953	..	..	470	5–10–5	..
	1954	241	31,640	1,530	5–10–5	..
	1955	321	60,640	1,000	5–10–5	1,06

Table 30. Number and Weight of Yearling Fathead Minnows Stock in Two Ponds on June 12, 1955, and the Standing Crop Yearlings in September, 1955

Pond	Initial stock per acre			Standing crop per acre*			Fertilizer	
	Pounds	Number	Mean length (inches)	Pounds	Number	Mean length (inches)	Pounds per acre	Ty
209	59	39,100	1.51	221	36,720	2.25	1,800	5–1
210	45	44,000	1.37	201	39,990	2.11	7,000	mar

* Includes only yearlings. Young were abundant, but only a small num were large enough to be retained by the gear employed in making popu tion estimates.

1.8 inches were stocked in two ponds in June 1955 (Table 30). were of salable size by September when the crop was harvested. weight gain per acre between stocking and the September harvest 162 pounds in Pond 209, and 156 pounds in Pond 210.

SILVERY MINNOW

Silvery minnows were stocked in 11 ponds. The adults stoc in two ponds did not reproduce although both ponds appeared suita for bait propagation. An outbreak of disease virtually eliminated entire hatch of young minnows in a third pond. The disease characterized by a rapid disintegration of the caudal fin and ofte portion of the caudal peduncle was destroyed before death occur Mortality was first noted on July 6, 1954 and several thousand yo were observed to die during the following 10 days. Only 200 yo were found when the pond was inventoried in the fall, but 60 per

the initial brood stock remained. The pond owners stocked addi-
onal adult silvery minnows in the spring of 1955, and an outbreak
the same disease eliminated most of the 1955 hatch.

The remaining eight ponds were inventoried at the end of the
st growing season.

EPRODUCTION

Schools of recently hatched fry were first seen in ponds during
e last two weeks in May. Spawning in any one pond was probably
nited to a period of 1 to 2 weeks.

Young silvery minnows overwintered in three ponds (301, 305
d 306) were not sexually mature in the following spring as I+ fish.
ıt, in Pond 302, where growth was rapid during the first year of
e, yearlings were mature in May.

The number of young per acre at the fall inventory in eight ponds
eraged 19,430 (see Table 32). The production of young in these
nds was low compared with the 35,200 per acre reported by Markus
939) and the 44,000 per acre reported by Raney (1942) in ponds
ocked with less than 1,000 adults per acre. In the ponds under
vestigation, the number of young at the fall inventory bore no
lationship to the number of adults stocked the preceding spring.
ggesting that degree of spawning success was chiefly regulated by
vironmental factors.

ROWTH

The short spawning season of the silvery minnow results in a
pulation of young which is uniform in length and usually large
ough by fall to be retained by a ¼-inch-mesh seine.

The mean length of silvery minnows at intervals following hatch-
g is shown in Table 31. By September young were salable as perch-
e bait in all ponds, and in three ponds (302, 310 and 311) most
the fish were salable as bass-size bait.

ANDING CROP

The standing crop of silvery minnows in eight ponds at the end
the first growing season ranged from 56 to 268 pounds per acre
able 32). Four ponds (301, 305, 306 and 308) with an average
nding crop of 58 pounds per acre were turbid with suspended
y. Secchi-disc transparency in these ponds varied between 11 and
inches during the summer. Clay turbidity was not a problem in

Ponds 302, 309, 310 and 311, and these ponds produced a mean fa
standing crop of 186 pounds per acre.

Table 31. Total Length in Inches of Silvery Minnows at Captu
in Ponds Initially Stocked with Adults*

Pond	First growing season			
	July	August	September	October
301	..	..	..	2.17 (0.01)
302	..	..	..	3.24 (0.03)
305	..	..	2.56 (0.02)	..
306	..	..	2.56 (0.02)	..
308	..	..	2.01 (0.01)	..
309	..	..	2.16 (0.01)	..
310	2.43 (0.01)	2.73 (0.02)	2.81 (0.02)	..
311	2.32 (0.02)	2.71 (0.02)	2.91 (0.03)	..

* Standard deviations of the means in parentheses.

Table 32. Standing Crop of Silvery Minnows at the End of C
Growing Season in Ponds Stocked with Adults

Pond	Stocking rate per acre	Standing crop per acre				Fertilizer	
		Pounds	Numbers in inch size classes			Pounds per acre	Type
			1–2	2-3	3-4		
301	700	60	..	21,420	..	900	5–10
302*	2,200	91	..	..	8,140	600	5–10
305	1,250	58	..	9,880	..	1,700	5–8–
306	490	57	..	10,770	..	1,300	8 8–
308	2,000	56	10,700	12,500	..	..	..
309	2,400	130	..	35,900	..	2,000	6 12
310*	1,100	268	..	20,150	5,400	1,200	6–12
						3,200	manu
311*	1,000	255	..	10,400	10,100	1,500	6–12
Mean.....		122	1,340	15,130	2,960	xxx	xxx

* Pond drained.

The silvery minnows in Ponds 302, 310 and 311 were marketed as ass-size bait in September, although most of the minnows were slightly nder 3 inches in length. In the remaining five ponds silvery minnows ad reached perch-size by fall. Ponds 310 and 311 produced over 0,000 bass-size minnows. The largest number of bass-size golden iners produced in one year was 12,000. But, disease, failure of adult lvery minnows to spawn, and limited spawning success resulted in w yields from 9 of 11 ponds. Soil turbidity may have contributed low fall standing crops in several ponds and further tests are needed determine the production which can be expected in silvery minnow onds.

BLUNTNOSE MINNOW

Propagation of the bluntnose minnow in ponds has been discussed Hubbs (1933), Cooper (1935), Langlois (1937) and Wascko and lark (1948). The spawning habits of the bluntnose are similar to ose of the fathead minnow (Van Cleave and Markus, 1929).

Three ponds were stocked at rates of 400 to 1,000 adult bluntnose innows per acre in 1953. Eggs were first observed in these ponds ring the last week in May and spawning continued into late August. he ponds were inventoried in October 1953, and in one pond where ung were overwintered a population estimate was made at the

ABLE 33. STANDING CROP AND MEAN LENGTH OF THE POPULATION IN FERTILIZED PONDS INITIALLY STOCKED WITH ADULT BLUNTNOSE MINNOWS IN THE SPRING OF 1953

Adults stocked per acre	Harvest or standing crop per acre				Mean length of young (inches)	Fertilizer	
	Item	Pounds*	Numbers in inch size classes			Pounds per acre	Type
			1–2*	2–3			
400	Standing crop (October 1953)	42	20,500	3,500	1.50	600	5–10–5
600	Standing crop (October 1953)	48	19,900	3,900	1.62	600	5–10–5
1,000	Standing crop (October 1953)	90	9,620	12,250	2.11	1,000	5–10–5
	Harvest (June-August 1954)	108	..	16,500	..	..	..
	Standing crop (October 1954)	78	4,250	10,500	..	1,400	12–12–6

* Small minnows inadequately sampled by gear employed. Total poundages and numbers of fish under 2 inches are minimum estimates.

end of the second growing season. The standing crop and mea length of the minnows at inventory are shown in Table 33.

The available data indicate that bluntnose minnows can reared in New York State ponds and marketed as perch-size bait. T yield of salable bait fish from bluntnose minnow ponds was low than that from the fathead minnow ponds discussed in a precedi section. The differences in production may have been the result dissimilar environmental conditions rather than an inherent differen between species. As a summer bait fish the bluntnose minnow is mu inferior to the fathead minnow because it is less tolerant of handli and transporting.

CHUB SUCKER

The chub sucker was considered by Embody (1933) to be a su able bait fish for pond propagation. However, data on productio were not published.

Ripe chub suckers, 5 to 7 inches in length, were stocked in Pon 404 and 405 at rates of 160 and 214 per acre, respectively. Pon were stocked in May 1953 and inventoried in the fall of 1953. Co mercial fertilizer was applied regularly during the summer.

Chub suckers stocked in Pond 404 did not reproduce successfu Of the adult stock 70 per cent was recovered in the fall inventory b no young were found.

In Pond 405 several small schools of fry were observed on Ju 10. The estimated population on September 10 was 4,250 young acre averaging 2.60 inches in length. The weight of the stand crop was 47 pounds per acre.

The inadequate reproduction of chub suckers in ponds may li the value of this species in bait propagation. Cooper (1935) observ that the lake chub sucker *(Erimyzon sucetta kennerli)* stocked Michigan ponds produced few young.

CONCLUSIONS

The golden shiner, white sucker and fathead minnow are suita for bait culture in New York State. Management recommendati for these species have been formulated from information reported this paper (Forney, in press).

New York ponds produce low yields of bait fish compared w ponds in more southern latitudes. Prather *et al.* (1953) reported standing crop of golden shiners in Alabama ponds averaged pounds per acre at the end of one growing season. Ponds stocked w

dult fathead minnows can be expected to yield over 300 pounds per ere in a 120-day period (Prather, *et al.*, *op. cit.*). Two growing asons were required to produce similar standing crops in fertilized ew York ponds.

Low yields tend to increase the cost of bait fish production. Since holesale bait prices in New York state are similar to those in Tenessee (Ruhr, 1953), profits from bait culture will be low compared ith returns from bait propagation in southern states. However, most tablished bait dealers cooperating with the author in this study condered the rearing of bait fish profitable as a means of supplementing eir supplies of wild bait from natural waters. The rapid expansion small bait-rearing facilities and increased use of farm ponds for aring bait fish is additional evidence that bait propagation is feasible New York State.

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THE PROBLEM OF SETTING DUCK HUNTING SEASONS IN NEW YORK[1]

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ABSTRACT

During the years 1948 through 1953 periodic aerial survey flights fro September through January were flown over the six main waterfowl regio of the State. Data from these surveys have been graphed to show the perio of abundance of dabbling ducks and diving ducks in the several regions. The data together with limited hunter bag check records, band returns, an weather information are discussed to illustrate the problems involved in setti equitable waterfowl seasons under the necessary basic framework establish by the U. S. Fish and Wildlife Service. It is concluded that the present seas dates for Long Island are almost ideal, and that the upstate season is reasonab equitable. However, an early opening date for the Lake Champlain regi is suggested, and there are strong differences of opinion regarding the impo tance of late-season gunning for diving ducks.

Thirty years ago, when waterfowl hunters in New York cou shoot ducks from mid-September to late December or even early Jan ary, there was no problem regarding the time of the open seaso Whenever the southbound flocks arrived in a locality, the hunte could try their luck. But, more recently, it has been necessary curtail the extent of the season because of a decreased supply ducks and an increased hunting pressure. In a state as large a as varied in character as New York this has inevitably resulted in loc

[1] A contribution of Federal Aid in Fish and Wildlife Restoration Proje W-39-R.

ssatisfaction when the open season failed to coincide with the time hen gunners felt the shooting would have been best. Although ery effort has been made to reduce such conflicts to a minimum, ey cannot be wholly eliminated in this State until a substantially nger open season generally can again be permitted. Some of the ajor factors involved are discussed in this paper.

In the first place, the over-all limits of the open season each year e set by the U. S. Fish and Wildlife Service. Within these limits[2], e states have some latitude to select the dates they consider most sirable. Until 1953 the dates selected in New York had to apply iformly throughout the State. In that year, however, a season on ng Island separate from that upstate was permitted. This was a ajor advance, but not a full solution.

In any case, a primary prerequisite to selecting the most appro- iate open season within the prescribed limitations is a knowledge the periods during which, on the average, duck abundance is ghest each fall in the major regions of the State. Adequate infor- ation of this sort for extensive areas is virtually impossible to obtain observation from the ground. Aerial observation, however, affords means of assessing relative abundance almost simultaneously over a de territory. By making successive flights throughout the fall, the ttern of migration can be determined.

The Department first experimented with fall aerial surveys of terfowl abundance in 1945, to provide data for use in setting and aluating hunting season dates in New York. By the end of 1947 ough records had been obtained to set up a flight route which ered a representative sample of the six main waterfowl regions the State—Long Island, the middle and lower Hudson valley, ke Champlain, the New York portion of the St. Lawrence River d eastern end of Lake Ontario, the southern shore of Lake Ontario d the Niagara River, and the Central Lakes region including the nor and major Finger Lakes, Oneida Lake and Montezuma marsh. r four seasons (1948 to 1951) eight flights were made each year, ming from September through January. In 1952 only five flights re made, and in 1953, three. The graphs accompanying this paper ve been prepared from the records obtained during this period.

Superficial examination of the data on a statewide basis suggests t New York's present duck season, from mid-October through late

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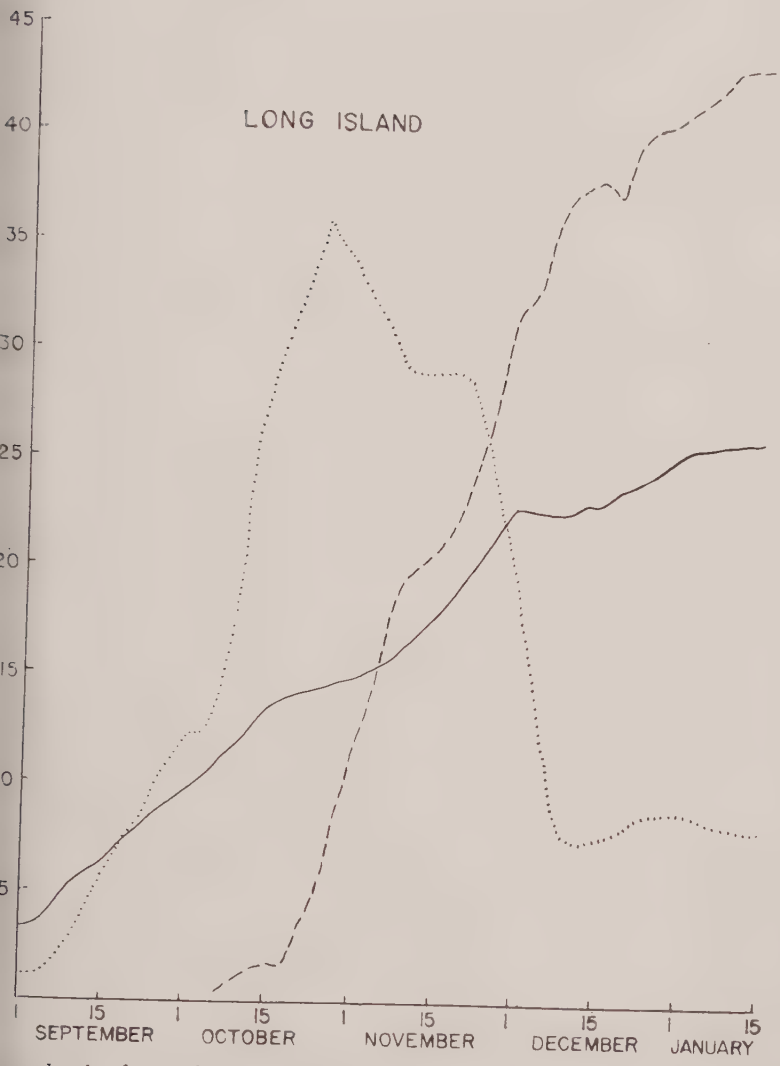
[2] The basic framework in 1956 allowed the State to select a 70-day continuous season, or a split season with a 10 per cent (7 days) reduction, sometime between October 1 and January 15.

Flight route followed in making aerial surveys of waterfowl abundance.

December upstate and from early November through early Janu on Long Island, comes very close to fitting the peaks of waterfo abundance in the State. Closer examination of the regional grap however, shows that these seasons are not quite as equitable as mig be desired. Some of the more specialized groups of waterfowlers certain localities feel strongly on this matter and frequently sugg that the duck flights have changed since the period when the d were recorded. Nevertheless, continued field work, though not intensive, indicates that this is not true, although some annual va tions do occur which affect hunting success.

Viewing the graphs for the individual regions, Long Island w its separate hunting season is considered first. Here, both the dabbl and the diving ducks build up quite steadily throughout the f However, it is not until about November 1 that adequate numb of either group have arrived to provide good shooting. Also, it advisable, as a safety factor, to have the season open as late as possi because most small boat owners keep their craft operating until win weather sets in. Scoters, with a special season in coastal waters fr October through December, are subject to shooting during

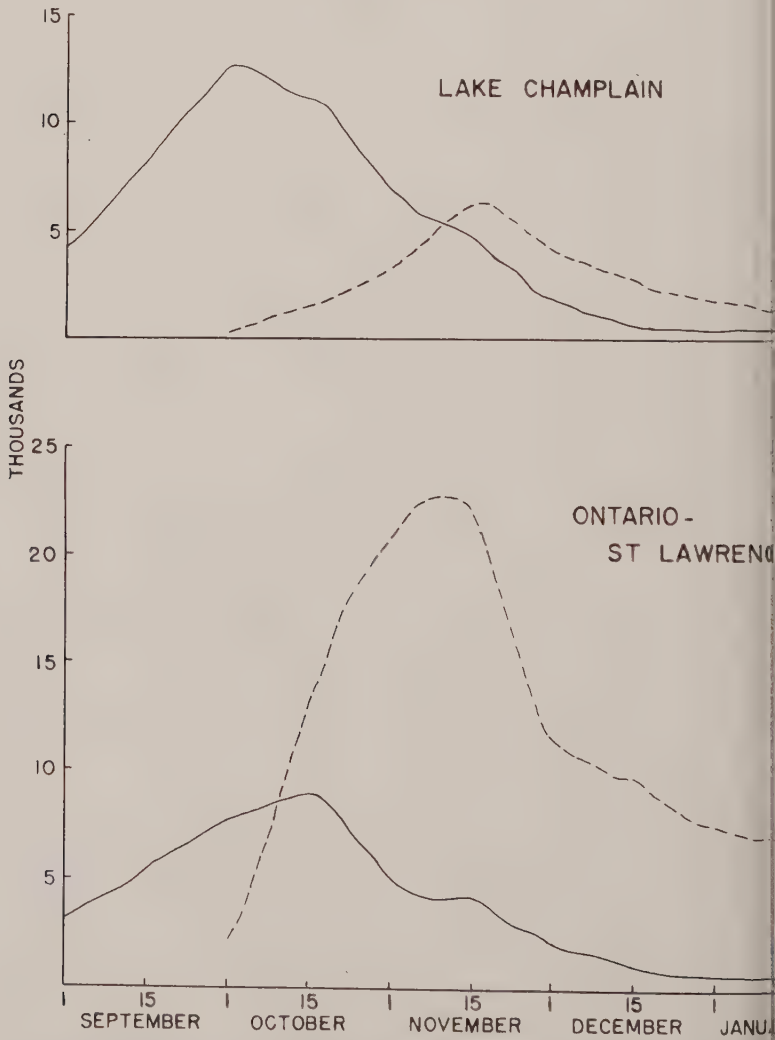


rage levels of waterfowl abundance during fall migration in the Long Island on of New York based on aerial surveys from 1948 through 1952. Solid line esents dabbling ducks; dash line, diving ducks; dotted line, scoters.

od of peak abundance. Generally then, the duck season dates for g Island seem almost ideally suited to both the hunter and the erfowl.

Moving up the river into the Hudson valley, the population is ely transient. Dabbling duck numbers start to build up rapidly

in late September, reach a peak about mid-October, and by e December they are well on the downgrade. Diving ducks are of c paratively low importance in this region although numbers h tended to increase in recent years. The present season appears adjusted to both ducks and hunters.



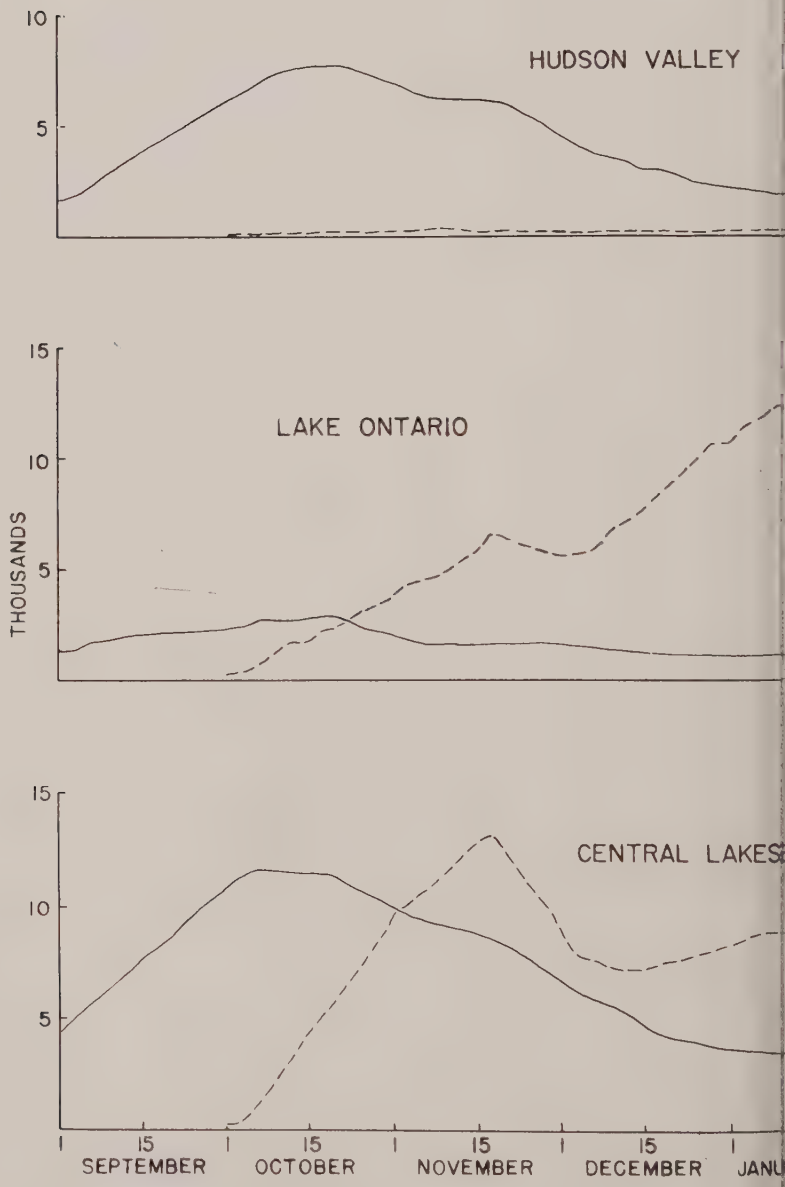
Average levels of waterfowl abundance during fall migration in the I Champlain and Ontario-St. Lawrence regions of New York based on a surveys from 1948 through 1952. Solid lines represent dabbling ducks; lines, diving ducks.

A step further north is Lake Champlain. Examination of the aphs for this region shows the peak of dabbling duck numbers occurng by October 1 and that abundance is well on the decline by the d of the month. Diving ducks reach their peak about mid-Novemr and are well down by December. This is a section of the State here an opening date before October 15 would be desirable—a logical e would be a date concurring with that in Vermont which in 1956 as October 5.

As one moves into the western part of the State, the problem comes more complex. In the Ontario-St. Lawrence region dabbling cks are at a high level by the first of October, but the real peak is ached about the middle of the month. Numbers usually remain asonably high into November. Diving duck abundance rises rapidly ring October, though the peak does not occur until near midvember. It then declines rapidly so that both duck numbers and ather make December a month of negligible importance to most terfowlers except in mild years. Some hunters favor an earlier ening, but, on the contrary, some of the dyed-in-the-wool whistler ooters look forward to December.

Along the open waters of Lake Ontario, the Niagara River, and ke Erie (the latter not included in the aerial surveys) dabbling cks do not play a major role in shooting, though present season tes include most of the hunting opportunity. In the marshes mediately adjoining the lake, however, these species are more portant, although hunting success is low due to heavy pressure. ving duck populations build up slowly in this area and rarely provide ich shooting even in November, but, as December weather arrives, ooting picks up along with a continued rise in numbers. As would expected, diving duck hunters in this region favor a later season, eferably one running into January.

Probably the Central Lakes region presents the most complex oblem. Viewing the graphs for this region, with dabbling ducks ching their peak in mid-October and diving ducks in mid-Novem-, it would appear that the present upstate season is well adjusted. r the dabblers it does fit very nicely. For the divers it fits conditions most of the smaller lakes where the harvest occurs mainly during vember and continues into December only when the weather is d. But on the large Finger Lakes Cayuga, Seneca, Keuka and nandaigua—though the greatest numbers of divers are present ing November, better shooting success is usually had in December. d local hunters believe that even better success might be obtained



Average levels of waterfowl abundance during fall migration in the Hu Valley, Lake Ontario and Central Lakes regions of New York based on a surveys from 1948 through 1952. Solid lines represent dabbling ducks; lines, diving ducks.

early January. Closer examination of the diving duck graph for region shows their abundance, after reaching a peak in mid-vember, dropping to a level little more than half as great between cember 10 and 15, and then rising gradually again into January. the present time what these shifts represent is not clearly under-od. No marked changes in species composition occur –scaups, heads and canvasbacks, which make up the principal diving duck , are all normally at their peaks in November and all seem to ow nearly the same curve. The dip and subsequent rise in late cember could represent the arrival of more ducks from the North, ulation shifts due to hunting pressure, or a northward movement birds that had gone further south. Nevertheless, despite the fewer ls present in December, the more wintry weather increases move-nt among them, and hunting success, for the comparatively few npletely equipped gunners, is much improved.

The situation in both the Central Lakes and Lake Ontario regions induced some diving duck hunters to favor either a later season a split season. In trying to determine the most equitable arrange-nt within the present Federal framework, various records that available in addition to the aerial survey data have been analyzed.

For several years Department personnel have conducted hunter checks throughout the State. These checks were made on the er water units on weekends during the open season. Examination he records for all sections of the State showed a decline in the portion of the total harvest taken as the season progressed. In the as where diving duck shooting was important, the last half of the on provided approximately a quarter of the total harvest. Yet total number of hunters was low during this last period and indi-ual bags were above average. In the Central Lakes and Lake ario regions especially, diving duck shooting at this season is a ialized sport and few hunters have the necessary equipment. hermore, good gunning sites are few, and good only when far een. Thus the number who can participate is small. In view his it seems evident that a later opening date would benefit only inor segment of the waterfowlers, while depriving the majority uch of their sport because it would miss the peak of dabbling duck dance.

What about the alternative of a split season? Essentially the same ments apply here as to a later opening date. With the relatively ly decline in the proportion of the total bag taken as the season nces and in the number of hunters afield, it is most unlikely that

the loss in hunting opportunity and harvest among the majorit hunters would be compensated for by the gain to the late-season di duck gunners. For almost any split season that could be selected u the present framework, much of the goose shooting, field hun of dabblers, and most of the potential hunting for divers upstate ex along the shores of Lakes Erie and Ontario and the Niagara R would be sacrificed.

Under existing circumstances, then, other than the desirabilit an earlier opening in the Lake Champlain region, the upstate se seems reasonably equitable. The possible exception would be a season beginning October 15 (as at present), with the break f December 1 to 15, and ending December 31 instead of Decembe The 8-day extension would represent the 15-day interval betw segments less the 7-day penalty for the split. This would leave the hunter still at the mercy of the weather with a sacrifice of seven on the gamble that the later weather would be more severe and af better gunning.

Regulations regarding the use of the waterfowl resource sh provide for as much harvest as possible without endangering species. In the Finger Lakes there may be a hunting potential respect to diving ducks that is not currently being realized. The wi banding program now in progress throughout the Atlantic fly should provide valuable data in relation to this question. So too few returns have been obtained from birds banded in New to shed much light on the extent to which they are being harve The returns appear few compared with those for dabblers, but ex ence is lacking for evaluating returns from winter-trapped ducks w must pass through one breeding season before being subjecte gunning. The returns do suggest when and where the ducks being taken. For the readheads, canvasbacks and scaups that been winter-banded in New York, nearly a third of the fall ha occurred before they reached this State; about half were take New York; the remainder were taken in states to the south and In terms of time, the returns show that some of these winter-ba ducks were present in New York waters in October and early No ber, though the main harvest did not occur until late November December. If the theory of underharvesting is proven, it ap that the possibility of devising some method of providing for a gr harvest of diving ducks might well be explored. But again, as n at the beginning, there will be little opportunity for a solution it becomes possible to grant a longer open season.

IEMICAL CHARACTERISTICS OF NEW YORK FARM PONDS[1]

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ABSTRACT

Data on temperature, oxygen, pH alkalinity, total dissolved solids, phosous, and nitrogen content were obtained in 48 central New York farm ds. These ponds exhibited considerable chemical diversity, with total linity concentrations varying from 5 to 226 p.p.m. Solute concentrations individual ponds fluctuated within broad limits in response to the inflow unoff and biological activity within the pond.

The chemistry of 48 farm ponds in central New York was studied 1953 and 1954 as part of an investigation of fish production. phasis was placed on the ranges of concentration of alkalinity, total olved solids, nitrogen, and phosphorus found in the surface waters these ponds, with some measure of the variation within individual ds. Oxygen, temperature, and pH of both surface and bottom er of eight ponds sampled periodically were determined.

The artificial impoundments studied varied from 0.2 to 4.0 acres surface area with maximum depths of 5 to 12 feet. Water was plied to most ponds by runoff from agricultural lands and to some nt by ground water. All ponds were located within a 60-mile ius of Ithaca, New York.

METHODS

Temperature was determined at a depth of 3 to 6 inches and he bottom in the deepest area of the pond with a thermistor thermeter accurate to 0.5° F. Oxygen tests were made by the sodium le modification of the Winkler method (American Public Health ociation, 1946), and pH was determined with a Hellige color disc parator. Water samples for oxygen and pH analysis were coled with a Kemmerer sampler or a modified rubber syringe bulb tube. For other chemical analyses, a single water sample was ected by submerging a glass jug slightly below the surface. Oxygen, and total alkalinity analyses were made in the field, while other lyses were made in the laboratory within 12 hours after the sample collected.

Total alkalinity was determined using a disodium 4, 4'-bis-2, 2'

contribution of Federal Aid in Fish and Wildlife Restoration Project F-4-R. . Alfred W. Eipper, Cornell University, and Ernest P. Snyder, U. S. Fish d Wildlife Service, assisted in the collection of field data.

stilbenedisulfonate indicator (Taras, 1948). Free ammonia was mated by nesslerization following distillation, and organic nitr by the Kjeldahl method (American Public Health Association, 19 Phosphate was determined by the ceruleomolybdic method, and phosphorus by the same method after oxidation with nitric (Taylor, 1937). Colorimetric comparisons were generally made a Lumetron 400 colorimeter. When concentrations of phosph and ammonia were low, color comparisons were made using milliliter nessler tubes. All phosphorus and nitrogen tests were in duplicate. The allowable difference betwen duplicates was at 0.01 p.p.m. Phosphorus is expressed as $PO_4^{\equiv}$, and ammonia organic nitrogen are reported in terms of nitrogen.

Total dissolved solids were determined by evaporation of a milliliter sample of filtered water (No. 40 Whatman filter pa using a water bath to control the temperature at which evapora proceeded. The standard deviation of an individual analysis determined from duplicate samples, was ± 3.8 milligrams.

TEMPERATURE, OXYGEN, AND pH

Temperature, dissolved oxygen, and pH values were reco at approximately 6-week intervals in eight ponds from Septembe 1953, to August 18, 1954 (Table 1). Temperatures were taken betw 8 a.m. and 5 p.m. Individual pond maxima of 84° F. at the sur and 79° F. at the bottom were recorded.

Summer thermal stratification in the ponds studied was c pronounced, but seldom persisted continuously more than 2 w Stratification was most evident in artifically enriched ponds. T perature differences between surface and bottom waters averaged F. in four unfertilized and 4.0° F. in four fertilized ponds inclu in Table 1. A probable explanation is greater plankton turbidit the fertilized ponds resulting in absorption of more radiant en in the surface waters. Secchi disc transparencies averaged 27 in in fertilized ponds compared with 49 inches in unfertilized ponds.

Oxygen concentrations in the surface waters of New York p are usually near saturation during the ice-free period of the y Temporary oxygen deficiencies occurred in the bottom waters of thermally stratified ponds in September 1953 and again in the sum of 1954. Both ponds were fertilized and oxygen depletions coinc with plankton pulses. Occasionally a supersaturation of oxygen present in subsurface water. This condition was noted when tr parent water permitted light penetration to weedbeds on the bot

Table 1. Seasonal Variation in Mean Temperature, Mean Oxygen, and pH Range in Eight Central New York Farm Ponds from September 1953 to August 1954

Location	Sampling period								
	September 1—5	October 14—21	December 1—7	January 16—19	March 1—5	April 8—11	May 28—31	July 9—16	August 16—18
	Temperature in degrees Fahrenheit								
Surface	80.2	55.5	41.6	34.1	33.4	50.9	65.9	74.4	75.2
Bottom	74.9	54.2	41.7	40.0	36.8	49.5	62.1	69.2	69.4
	Oxygen in p.p.m.								
Surface	7.1	9.6	9.3	9.7	16.4	11.0	10.2	8.4	10.2
Bottom	4.0	9.4	11.9	7.4	16.1	11.2	10.1	7.8	8.6
	pH								
Surface	8.4—7.4	7.4—7.8	7.2—7.4	7.2—8.2	7.1—8.0	7.0—8.4	8.1—9.0	8.0—8.4	7.4—9.5
Bottom	8.4—7.2	7.4—7.6	7.2—7.4	7.0—7.8	7.3—8.3	7.3—8.4	8.1—8.5	7.8—8.4	7.2—9.5

The range in pH was from 7.0 to 9.5 for both surface and bott waters. Values of 8.5 to 9.0 were common during the summer w values of 7.2 to 7.8 generally prevailed in winter.

TOTAL ALKALINITY

Total alkalinity of natural waters is principally a measure of carbonate content expressed in terms of calcium carbonate. In central New York ponds the range in total alkalinity was from 5 to p.p.m. Values were highest in the Lake Plains region bordering L Ontario and generally low in the Southern Tier counties adjacen Pennsylvania. This trend reflects the lime content of the underly soils.

Total alkalinity of a pond varied considerably. In 13 pond which at least seven analyses were made over 6- to 12-month peri the range in alkalinity was 42 to 92 per cent of the mean alkalin Total alkalinity concentrations were often low in summer and high winter (Table 2). This tendency possibly results from the biog precipitation of carbonates during summer and the return to solu of carbonates in winter when assimilation is limited by low water t perature.

Table 2. Seasonal Variation in Total Alkalinity Concentrati (in p.p.m.) in Central New York Farm Ponds from Decem 1953 to August 1954

Month	Pond					
	1	4	15	33	48	4
December	73	80	105	130	90	9
January	113	92	71	156	110	9
March	80	70	40	124	92	7
April	64	48	42	124	85	8
May	54	55	70	90	76	6
July	98	74	100	97	80	4
August	84	70	70	97	84	4

In several ponds minimum alkalinity concentrations were reco in March and April 1954 (Table 2). This late-winter declin alkalinity coincided with the inflow of considerable surface ru Bryant (1948) found that the calcium content of surface runoff f Dunkirk and Ontario soils at Geneva, New York, ranged from to 11.6 p.p.m. This would be equivalent to an alkalinity of 6. 29.0 p.p.m. assuming the calcium was combined with carbonate solution. Ponds on the same soil types seldom have alkalinity

trations less than 80 p.p.m. The tendency for surface runoff to er pond alkalinity is apparently counteracted to some extent by inflow of percolate water which is richer in carbonates.

TOTAL DISSOLVED SOLIDS

The total dissolved solid concentration in 42 central New York nds ranged from 50 to 420 p.p.m. As expected, high total dissolved d values were associated with high total alkalinity concentrations. e correlation between total dissolved solids and alkalinity in 42 nds was $r=0.84$ ($P>.01$). A correlation of $r=0.42$ ($P>.01$) existed ween total alkalinity and the noncarbonate substances (determined subtracting total alkalinity from total dissolved solids) indicating ters high in carbonates are generally high in other solutes.

Within a pond, changes in the concentration of total dissolved ds were not directly correlated with fluctuations in total alkalinity able 3). Biogenic precipitation of calcium carbonate and temporary

BLE 3. SIMULTANEOUS DETERMINATIONS (IN P.P.M.) OF TOTAL ALKALINITY AND TOTAL DISSOLVED SOLIDS IN THREE CENTRAL NEW YORK FARM PONDS DURING SUMMER, 1953

nd	Item	Sampling period				
		May	June	July	August	September
3	Alkalinity	107	116	110	77	86
	Total dissolved solids	247	214	232	328	250
)	Alkalinity	130	142	176	130	150
	Total dissolved solids	270	304	252	248	269
ł	Alkalinity	180	171	98	119	138
	Total dissolved solids	211	244	230	207	227

LE 4. TOTAL ALKALINITY AND TOTAL DISSOLVED SOLID CONCENTRATIONS (IN P.P.M.) IN CENTRAL NEW YORK FARM PONDS DURING FEBRUARY AND DECEMBER, 1953

)nd	February		December	
	Alkalinity	Total dissolved solids	Alkalinity	Total dissolved solids
1	33	68	84	141
4	32	108	90	211
5	31	95	47	120
3	115	174	130	198
5	50	124	58	191
9	66	97	90	134

increases in dissolved organic material following rapid decompositi of plant material may be factors of importance in causing chan in the relative concentrations of total dissolved solids and total al linity. Seasonal changes in precipitation may also influence the ra of total dissolved solids to total alkalinity.

The surface waters of six ponds were analyzed for total dissol solids and total alkalinity in February and again in December, 19 On both occasions the ponds were ice-covered. Considerable run occurred in the winter of 1952-53 prior to the February analyses, wh the samples for December 1953 were collected prior to the period heavy winter runoff. Both alkalinity and dissolved solid concentrati were consistently higher in December than in February (Table but the ratio of dissolved solids to alkalinity did not remain consta

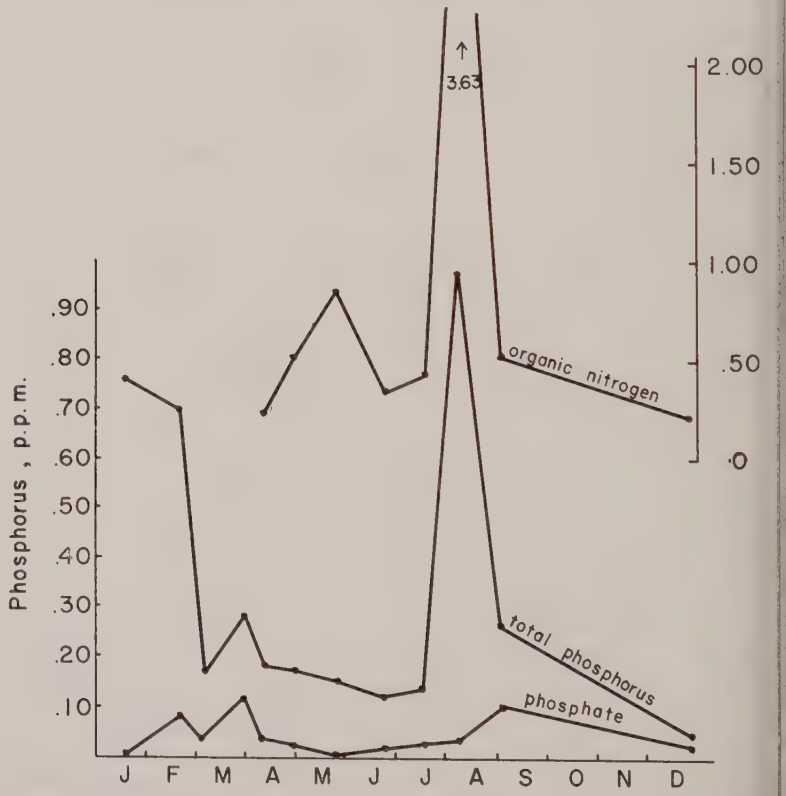

Figure 1. Monthly variation during 1953 in the concentrations of orga nitrogen, phosphate and total phosphorus in the surface wate Pond 33.

PHOSPHORUS

In recent years emphasis has been placed on phosphorus as a limit-g factor in the productivity of inland waters. The total phosphorus ncentration of pond water consists of two components: the inorganic phosphate fraction and the organic fraction which is bound in ganic compounds. A phosphorus reserve exists in the bottom sedi-ents that exerts a profound influence on the phosphorus concen-ation of the water. This exchangeable fraction may be of primary portance in determining the fertility of shallow impoundments ch as farm ponds.

A series of samples for phosphorus analysis was taken from Pond at approximately monthly intervals during 1953. High concentra-ns of total phosphorus were observed in January and February d again in September (Figure 1). The January and February lues of 0.76 p.p.m. and 0.70 p.p.m., respectively, apparently resulted m an influx of surface water from a watershed fertilized with anure early in January. This was indicated by the concentration of osphorus found in water entering the pond. Although the actual antity of phosphorus contributed by the watershed could not be asured, the phosphorus concentration of inflowing water was deter-ned during periods of heavy runoff in January, February and arch. Composite samples of water from several rivulets contained e following concentrations (in p.p.m.) of phosphorus after filtration:

	Phosphate	Total phosphorus
January	0.80	1.76
February	0.42	0.92
March	0.36	0.86

In a flow of subsurface water entering the pond from a tile sys-n, the total phosphorus concentration gradually declined from 0.32 .m. in February to 0.043 p.p.m. in June.

Runoff entering this pond between late June and August 8, 1953, s negligible, yet the total phosphorus concentration of the surface ter increased from 0.13 p.p.m. in late June to 0.96 p.p.m. on gust 8. Most of the phosphorus in August was bound up in a se phytoplankton bloom. The rise in phosphorus between June l August indicated a large exchange of phosphorus between the tom sediments and the seston. This pond, with an average total alka-ty of 104 p.p.m. and bottom deposits high in organic matter, meets requirements for high phosphorus exchange suggested by Barrett 53).

The surface waters of several ponds within 10 miles of Itha were analyzed for total phosphorus in the months of February, Aug and December of 1953. The analyses (in p.p.m.) are presen below with comparable data for the three months from Pond 33:

Pond	February	August	December
1	0.15	0.10	0.01
4	0.05	0.19	0.02
5	0.22	0.72	0.03
33	0.70	0.96	0.04
45	0.19	0.21	0.02
49	0.10	0.26	0.03

Both February and December samples were taken through an cover, yet phosphorus concentrations observed in February were u formly high compared with December values. In Pond 33 the h phosphorus concentration detected in runoff water could acco for the February phosphorus level of 0.70 p.p.m. Since the waters of this pond was fertilized during the winter there remains some do as to whether runoff water from unfertilized land would carry sufficie phosphorus to account for the February values found in other pon Duley (1926) determined the dissolved phosphorus content of run water from six plots in Missouri. Samples from cropland, represent the runoff from several rains, contained 0.12 to 5.00 p.p.m. of ph

Table 5. Mean and Range of Phosphate and Total Phosphorus C centrations (in p.p.m.) in Fertilized and Unfertilized C tral New York Farm Ponds

Item	Fertilized ponds		Unfertilized ponds	
	Phosphate	Total phosphorus	Phosphate	Total phosphor
May—September				
Number of ponds	13		13	
Mean	0.16	0.33	0.03	0.14
Range	0.00—0.38	0.07—0.60	0.00—0.12	0.02—0.
November—March				
Number of ponds	7		15	
Mean	0.08	0.17	0.00	0.07
Range	0.00—0.36	0.05—0.48	0.00—0.01	0.01—0.

horus. These data tend to support the conclusion that runoff could cidedly increase the winter phosphorus level in ponds.

Phosphate and total phosphorus concentrations were higher in rtilized than in unfertilized ponds in the summers of 1953 and 1954. osphorus concentrations in fertilized ponds remained higher than ose in unfertilized ponds during the winter (Table 5).

NITROGEN

Combined nitrogen in water exists as inorganic compounds such ammonia, nitrates, and nitrites, as well as in organic compounds. the present investigation only ammonia and organic nitrogen were termined.

A range of 0.00 to 0.16 p.p.m. appears to represent the normal ncentration of ammonia in unfertilized ponds in central New York. fertilized ponds concentrations of ammonia up to 0.45 p.p.m. have en detected (Table 6), but this concentration is well below the 2.5 p.m. considered toxic to fish by Ellis, Westfall and Ellis (1946).

Organic nitrogen concentrations during the summer were over 50 p.p.m. in 11 fertilized ponds and under 0.45 p.p.m. in 8 unfertilized ponds (Table 6). Concentrations were lower and differences

BLE 6. Mean and Range of Ammonia and Organic Nitrogen Concentrations (in p.p.m.) in Fertilized and Unfertilized Central New York Farm Ponds

Item	Fertilized ponds		Unfertilized ponds	
	Ammonia	Organic nitrogen	Ammonia	Organic nitrogen
	May—September			
mber of ponds	11		8	
an	0.26	1.14	0.07	0.36
nge	0.10—0.45	0.51—1.80	0.00—0.27	0.28—0.45
	November—March			
mber of ponds	7		14	
an	0.01	0.41	0.01	0.20
nge	0.00—0.02	0.23—0.50	0.00—0.12	0.06—0.35

ween fertilized and unfertilized ponds were less pronounced in nter than in summer. Higher winter values may occur during riods of heavy runoff. Bryant (1948) found the dissolved organic

nitrogen in surface runoff from Ontario and Dunkirk soils at Gene New York, varied between 1.0 and 9.5 p.p.m.

A series of samples from Pond 33 (Figure 1) indicated la fluctuations in organic nitrogen concentrations may occur. The p concentration of 3.63 p.p.m. was recorded during a plankton pulse

CONCLUSIONS

The chemical diversity of central New York ponds is appar from the range in alkalinity of 5 to 226 p.p.m. and in total dissol solids of 50 to 420 p.p.m. Proper fish management of waters show such diverse characteristics may necessitate the classification of po on the basis of their solute content.

Runoff has a pronounced transitory influence on the solute c centration of ponds in this section. Runoff generally reduced t alkalinity and total dissolved solids, and increased phosphorus c centrations. Fertilization of a pond watershed can cause a mar increase in the nutrient concentration of the pond water.

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CONTROL OF MUSKRAT BURROW DAMAGE IN EARTHEN DIKES[1]

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ABSTRACT

In studying means of controlling muskrat damage to earthen dikes, vegeta-n-free areas immediately adjacent to such structures could not be related to extent of burrow damage.

Tests were made of muskrat-proof materials on the face of dikes and as tical barriers within dikes. Netting made from ferrous metals was found be impractical because of high cost and rate of decomposition. Aluminum ting deteriorated rapidly in acid, organic soils.

Observations indicated the use of asbestos-cement sheets as vertical barriers hin dikes to be the most practical of the various methods tested. Vertical riers have the added advantage of helping to correct damage after it has urred.

Berms under certain conditions were considered to be an effective deterrent muskrats.

Chemical control with calcium carbide may be an effective but temporary trol measure.

Some dikes constructed of inorganic, heavy-clay soils were not damaged muskrats over a period of several years even though a substantial muskrat pulation was present.

It was concluded that it should be both practical and economical to limit trol measures to dikes in which muskrat damage had become serious.

Throughout the nation the retention of run-off water behind then dikes has been gaining impetus in recent years both as a ans of flood control and to improve conditions for wildlife, ecially waterfowl. In New York, over 880 small marshes have been ated or enlarged since 1949 under the Department's wildlife habitat provement program. Such impoundments result, generally, in ractive environments for muskrats.

Coincident with this increase in total environment for these ents has been a strong and increasing decline in the prices paid trappers for raw furs (Cook, 1956). The intensity of muskrat vests, and, hence, the degree of population control, is related ectly to these prices (Cook, 1952).

In the study reported here an effort was made to evaluate certain ects of muskrat life history which relate to burrow damage control various means for reducing such damage. It was initiated in il 1953 and terminated in March 1957.

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contribution of Federal Aid in Fish and Wildlife Restoration Project -80-R.

PROCEDURE

Tests were conducted to determine the effectiveness, in prevent muskrat-burrow damage, of placing hardware cloth or poultry nett on the face of a dike, or asbestos-cement sheets within it. The abi of aluminum netting to withstand being buried in waterlogged was evaluated, and observations were made on the value of st rip-rap and earth compaction in the control of burrowing. The va of berms on dikes, as protection for them, was also considered.

Burrow characteristics were studied in relation to the point entrance into the dike, changes in the burrow system with time, a the distance to a food supply.

FINDINGS

Muskrat-proof barriers were found to be effective in prevent burrow damage under certain conditions. Hardware cloth or pou netting put in place before damage had occurred resulted in compl even though temporary, control. When put in place after damage h occurred, such material was effective only if muskrats were elimina from the dike before the barrier was installed. Poultry netting gauge) deteriorated rapidly and there was some evidence, altho inconclusive, that muskrats gnawed through it to gain entrance i the dike. Heavily galvanized hardware cloth has remained an effec barrier for about 4 years.

Aluminum netting, because of its weight, would be the m efficient material tested, in terms of cost, if it could withstand somewhat extreme conditions in waterlogged soils. In this connecti J. J. Moroney, Chief Chemist of the Aluminum Company of Ameri stated that it would probably corrode if subjected to conditions countered in water-saturated soils.[2] Under test, it did deterio seriously in an acid, organic soil within 6 months.

After a dike has been extensively damaged by muskrat burro a barrier placed within the dike may represent a positive, practi solution to the problem. Asbestos-cement sheets[3] appear to be ide suited for a vertical, internal barrier because of low cost, extr resistance to deterioration, and ease of handling. A dike which ineffective because of burrow damage was treated with 300 feet of material in the spring of 1956. It has maintained its rigidity hardness, corrected the initial damage and prevented additio burrows.

[2] Personal communication, 1953.
[3] Supplied by the National Gypsum Company, Buffalo, N. Y.

Stone rip-rap may function to prevent muskrat burrow damage, t observations at the Howland's Island Game Management Area d the Delmar Game Farm suggest that in time (10 to 20 years) mage may result in spite of this expensive precaution.

Earth compaction with a sheepsfoot roller is generally considered sirable in the construction of earth dams. Further, such soil treat-ent would seem to deter burrowing muskrats. Yet, R. A. Reed, Area nservationist, U. S. Soil Conservation Service, Belmont, N. Y., ted that he has found no observable differences in the extent of mage between compacted and noncompacted dikes, and that "This uld lead me to conclude that the use of the sheepsfoot rollers did t compact the earth hard enough to prevent the burrowing by uskrats".[4]

ure 1. Level berm on dike in Tioga County. Note absence of burrows and wave erosion.

Several berms were observed, one of which had been effective 4 years in preventing damage to the dike proper (Figure 1). A m is a level extention of the normal dike into the impounded area.

[4] ersonal communication, 1954.

In the dikes studied, the mean depth below the water surface which muskrats dug their burrows (floor of the burrow) was appro mately 7 inches, with a range from 0 to 20 inches. Beshears a Haugen (1953) noted burrow characteristics in Alabama clo comparable to those observed in New York.

No correlation between the location of a muskrat food supply a burrows was noted.

DISCUSSION

In any attempt to evaluate natural or artificial measures for c trolling damage to dikes by muskrats, it is necessary to consider certain aspects of muskrat activity that may relate to control. In connection it is frequently assumed that there is a direct relations between the food supply and the location of muskrat burrows, p viding burrowing sites are available. Muskrats, when submerged, sw at about 2 miles per hour, or approximately 60 yards a minute. Th may remain submerged following the first dive for as long as minutes. Thus, it is evident that the extent of vegetation-free ar generally encountered in wildlife marshes offers no real obstacle muskrats in obtaining food, even when they must swim under ice fo

Muskrat burrows tend to become more complex with the len of time they are in use. When first constructed in heavy clay s they penetrate only a short distance (3 to 5 feet) and then t upward. Burrows which have been in use for 5 or more years n have from one to three entrances; complexly branched tunnels n parallel the long axis of a dike together with passages at right an to it. Burrow damage to dikes constructed of such soils, which w the ones usually encountered during this study, is seldom of a crit nature for the first 3 or 4 years, sometimes much longer, even tho it may be evident that a substantial number of these rodents h burrowed into a structure. In time, however, the dike may be we ened, and severe leaks and erosion may result.

Barriers, such as steel netting placed on the face of dikes im diately following construction, were effective in preventing dam throughout the period of the investigation. The upstream faces of d treated had a 3 : 1 slope. Water loss exceeded inflow during e summer observations were made, with the result that the water le in the marshes under observation dropped about 10 to 18 in annually. Therefore, such a barrier would need to be at least 5 wide.

The placement of such materials as metal netting after dam

l occurred and when muskrats were not eliminated from the dike s not effective in protecting the structure. Under such conditions, muskrats tunneled under the barrier and continued to use their rows. It was found to be virtually impossible to excavate entire row systems and thus eliminate the occupants. Further, the cost such treatment would be prohibitive.

In any case, the use of relatively inexpensive metal netting must considered of temporary value because of the high rate of deteriora- n of iron and its compounds in or on water-saturated soils.

Vertical barriers placed within but as close to the leading face the dike as is feasible appear to be practical for the control of row damage. The asbestos-cement sheets (4 x 8 feet) tested during s study are relatively inexpensive as compared with metal products, l they are not influenced by pH ranges normally encountered in terlogged soils nor by changes in oxidation-reduction potentials. was suggested by chemists of the company that supplied the test terials that the rigidity of the sheets would be enhanced by contact h water. Thus, it is probable that such a barrier would have a h degree of permanency.

To install a vertical barrier in a dike that had become ineffective ause of burrow damage, a mechanical ditcher was used to trench dike so that 2 feet of the barrier when in position would be above l 2 feet below the normal water level. Placement in this manner ured a reasonable safety factor as it is unlikely that muskrats would row below the sheets, and, if they attempted to go over the barrier, ir burrows would be at or near the surface.

The advantages of such a treatment are that it may be applied r damage has occurred and total costs should not exceed 50¢ per al foot at present prices for ditching, labor and material.

Berms may be a practical measure for protecting dikes from row damage under certain conditions. When emergency spillways t be large to meet engineering specifications, soil in excess of that ded for the dike may be available. In such cases construction of rm as an integral part of the dike would have merit. Of the five ns observed during this investigation, none was seriously damaged nuskrats although burrows had been dug into them, in one instance ar as 2 feet. At the time of observation these efforts seemed to have n abandoned.

The use of chemicals in eliminating muskrats from dikes has been d in Missouri. Hicks, indicating good results were obtained follow-

ing the use of calcium carbide, stated "In using carbide we probe face of the dam to be treated with a crowbar or small auger to a de just below the water line. These probings are usually made some t or three feet up the side of the dam from the water line and are spa about three feet apart on the contour. After the probe is made ... we drop a few grains of carbide in each hole and tamp it shut. ... We have used it [this method] for two or three years and found it qu effective."[5]

Calcium carbide is known to be toxic to fish. What effect its in dike soils would have on fish life within impoundments is unkno but, presumably, this was not a problem in Missouri. Such chemi treatment, however, must be considered of temporary value. Furth more, labor and travel costs, if relatively frequent applications w required, would in time exceed expenditures for a permanent barr

Many dikes composed of inorganic, heavy-clay soils ("C" horiz have not been damaged by muskrats even though they have b functioning for 7 or more years. Muskrats have been present in impoundments created by these dikes in all instances, and in som substantial population was present. No explanation can be offered the lack of damage.

Thus it becomes increasingly apparent that some of the di developed under the wildlife marsh program in New York may n be seriously damaged by burrowing muskrats. Therefore, treatmen prevent burrow damage to all dikes developed in the future may no necessary. For those that have had their effectiveness serio impaired or endangered by muskrat burrows, costs for control sho not exceed greatly those which would have been incurred by pla vertical barriers prior to damage. Thus, it should be both pract and economical to limit treatment to dikes in which damage become serious.

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FOX POPULATION DENSITIES IN RELATION TO RABIES[1]

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ABSTRACT

In order to appreciate more fully the effect of a long-continuing rabies ootic in foxes on the population of these animals, a technique was devised comparing population densities in various areas. Several towns in the ies-enzootic region of the State and several towns in the rabies-free region e trapped nearly simultaneously by experienced trappers. Traps were not less than one-half mile apart and the number of traps used was deter- ed by the land area of the town. Records of the catch were kept and the a presented as trap nights per fox. Each town was trapped for 10 consecu- nights in 1955 and 1956.

Comparing the data for the rabies-free and the rabies-enzootic regions ws a significantly higher fox population in the non-infected region. Some erences existed between individual towns in each region which probably ected variations in the ecology of these towns. From these findings it is imed that certain barriers exist which prevent the spread of rabies into high populations in areas adjacent to the enzootic region. Several man-made natural barriers appear to exist which limit the spread of rabies.

Foxes appear to be the principal vectors of rabies in New York te, and, in spite of continuing prevalence of the disease in the south- tral counties, populations appear to be maintained at a sufficiently h level to perpetuate the enzootic. In order to appreciate more fully effect of the disease on populations and in an effort to study the ootiology of rabies in this State, a method of determining the rela- abundance of foxes was considered essential. Gier (1948), Johnson 51), and Wood (1954) have stressed the importance of determin- the population levels of foxes as the first step in an organized plan ontrol rabies in these animals, and, in turn, in other species as well. Census methods recommended by other workers in the field all

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[2] full-time loan to the New York State Health Department.

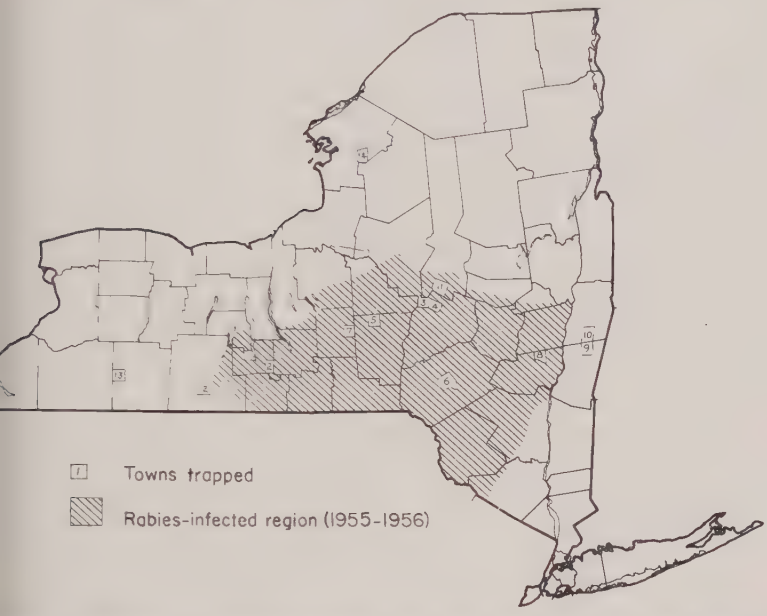
had serious limitations to their application in New York State. A la of suitable primitive roads rendered the technique of Wood (195 unusable. Two techniques previously used in this State, one a mo fication of that of Scott (1941), the other proposed by Cook (194 and similar to the scent-station index discussed by Richards and Hi (1953), were both considered unsuitable. Fluctuations of local fo supply influence the range and amount of movement of foxes, wh variable weather makes the reading of sign possible only under loca favorable conditions which are not uniform from year to year or ov a large portion of the State simultaneously.[3] Accordingly, a m practical technique for comparing the fox populations in various ar of the State was developed.

PROCEDURE

In order to evaluate the effect of rabies on fox population densit in the rabies-enzootic region of the State, areas for study were selec from the enzootic region and the region from which rabies had n been reported. The areas selected were towns or well defined portio thereof. Fourteen towns were included (Figure 1), and all data w collected as nearly simultaneously as possible.

The "trap-night-per-fox" method, with removal of trapped in viduals to prevent the possibility of retrapping, was considered to the best method of studying populations. The land area of each to was readily available (U. S. Bureau of the Census, 1942) and ea of the 14 trappers was instructed to set a total number of traps eq to half the land area in square miles. To insure adequate distributi over the area involved, traps were located not closer than one-half m apart, and sites were marked on topographic maps for later inspecti to insure freedom from concentrations in smaller areas which mig appear to the individual as more likely to be the habitat of fo The traps were left set for 10 consecutive nights and, once set, w not moved except at the request of landowners whose pets or livest might be endangered; such requests required relocating less than 1 p cent of the traps. Daily trapping records were kept to indicate t number of foxes caught, trap numbers of those traps catching fo and the number of traps sprung or catching other animals. In ad tion, weather conditions were noted if the trapper felt they might al the ability of the traps to take foxes. The species, red *(Vulpes fulv*

[3] Colson, R. B., N.Y.S. Conservation Department, personal communicati 1955.



ure 1. Relation of towns trapped for fox population data to rabies-infected region of the State. Towns are numbered to correspond with area numbers in accompanying tables.

gray *(Urocyon cinereoargenteus)*, and sex were also recorded on the ly records.

Those engaged in this work were all professional trappers, for the st part regular rabies control trappers employed by the Conservation partment and trapping foxes in the manner described by Colson McKeon (1952). Three were regularly assigned to district game nagers of the Conservation Department to handle wildlife damage nplaints. All used the common "dirt hole" set as well as the same s and lures.

Insofar as was possible the same individuals were assigned to the e towns both years. Because of changes in personnel, three towns e trapped by different trappers in 1956 than in 1955. The same pper worked in both Columbia and Greene Counties both years. e same trap sites were used both years whenever possible, but nges in land use made identical sites impractical in some instances. such cases the new sites were made as near the previous sites as ible and in such a way as to minimize the chance of altering trap- success. All the regular rabies control trappers were under the

direct supervision of a rabies control coordinator or one of his t supervising trappers.

The trapping was done during the last part of September and t first part of October in 1955 and 1956 (Figure 2). The most northe area was trapped entirely during the month of September because the earlier opening date of the small game hunting season. A seco area was trapped in part in September and in part early in Octo to allow the trapper to work another area. All other trapping w done during the first 20 days of October to allow completion of t program before the opening of the small game hunting season in t southern zone of the State. Minor variations in the exact dates of t trapping occurred, but most of the 10-day periods overlapped, maki the trapping nearly simultaneous.

Eight of the towns selected were in the rabies-infected region the State as shown in Figure 1 and Table 1. Rabies was reported 1955 from all of them but two, and the latter, in addition to being w within the enzootic region, were each adjacent to two other tow where cases were reported in 1955. Of these same two towns, one h

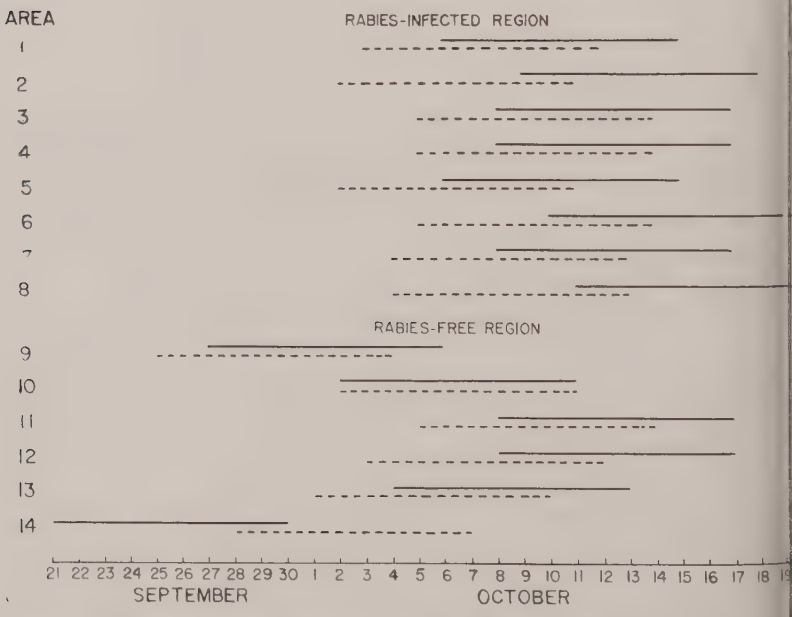


Figure 2. Periods during which trapping was done on the various areas, sh ing the degree to which they were simultaneous. Solid li represent 1955; broken lines, 1956.

ies reported from it in 1956 and one did not, but the latter was rounded by towns in which cases were reported the same year. ree of the towns from which rabies was reported in 1955 did not e cases recorded in 1956. None of the rabies-infected areas had n trapped for several months preceding the trapping for data.

BLE 1. Occurence of Reported Rabies (in any species) from 1950 to 1956 in the Areas Studied

Area	1950	1951	1952	1953	1954	1955	1956
Rabies-infected region							
1	..	..	..	..	..	x	x
2	x	..	..	x	..	x	x
3	x	..	..	..	x	..	..
4	..	..	..	..	x	..	x
5	x	x	..	..	..	x	..
6	x	x	x	..	x	x	..
7	x	..	..	x	x	x	x
8	x	x	..	x	x	x	..
Rabies-free region							
9	..	x	x	..	..	..	..
10	..	x	x	..	..	..	..
11	x	..	x	..	..	..	x
12	..	..	..	..	..	..	..
13	..	..	..	..	..	..	..
14	..	..	..	..	..	..	..

Six of the towns selected were considered rabies-free.[4] No cases e reported in 1955 and none had been recorded for two or more rs. Three of these have never had reported cases of rabies; two e well removed from the enzootic region, while the other was near western limit of the slight extension that occurred in Steuben nty in 1956. For the remaining three towns rabies had been orted at some time during the five years preceding 1955. Also, in of them (Area 11), one case of bovine rabies was recorded in 6. This appears to have been an insolated instance and, since the population does not seem to have been affected, it was ignored.

is known that many cases of fox rabies go undiagnosed and unreported ch year from the enzootic region. Only laboratory-confirmed cases were nsidered in determining the status of areas in this study. Also, Area 11, in uthern Herkimer County, was considered rabies-free even though within e cross-hatched territory as shown in Figure 1 because only one case of vine rabies was reported in 1956, and none had been previously reported several years.

FINDINGS

All data are expressed as trap nights per fox, i.e., the number traps set times the number of nights set divided by the number foxes caught. For example: 26 traps set for 10 nights resulting in total catch of 13 foxes equals 20 trap nights per fox. The trap nig per fox is a reciprocal of population density; in other words, the mo trap nights per fox the lower the population. Using the above examp but changing the total catch to 26 instead of 13 results in 10 tr nights per fox, or twice the catch, indicating a greater populati density.

The results of the trapping are presented in Table 2. The var tions in numbers of trap nights per fox for the rabies-free region compared with the rabies-infected region have been tested statistica using the standard error of the difference between means method. F 1955, the difference between the means for the two regions is significa at the 1 per cent level; while the difference for 1956 is significant the 3 to 4 per cent level. By combining the two years, the differen between the two regions is significant at the 0.1 per cent level. T

Table 2. Results of Fox Trapping

Area	Town	County	Trap nights per fo	
			1955	1956
Rabies-infected region				
1	Reading	Schuyler	9.6	33.5
2	Catharine	Schuyler	24.6	30.0
3	Plainfield	Otsego	15.0	50.0
4	Exeter	Otsego	22.8	12.3
5	Otselic	Chenango	38.0	23.8
6	Hamden	Delaware	10.0	8.3
7	Taylor	Cortland	21.4	12.5
8	Greenville	Greene	36.8	12.3
Mean			22.3	22.8
Rabies-free region				
9	Chatham	Columbia	8.2	26.0
10	Nassau	Rensselaer	18.3	20.0
11	Columbia	Herkimer	10.5	10.0
12	Rathbone	Steuben	10.0	9.0
13	New Hudson	Allegany	8.5	7.0
14	Rutland	Jefferson	10.0	9.2
Mean			10.9	11.3

* Data not included in statistical analysis as indicated in discussion.

ta from Columbia County in the rabies-free region were not included the statistical analysis for reasons discussed later.

DISCUSSION

By inspection of Table 2 it is apparent that considerable difference fox populations existed not only between the rabies-free and rabies-fected regions but between the various towns within the regions. It interesting to note that one area, the town of Reading in Schuyler unty, had its first report of rabies in several years only a short time fore the 1955 trapping began and experienced a sharp reduction in population as the disease progressed as evidenced by the 1956 data. rapid decline of this sort in a fox population is usually experienced the face of an outbreak of a lethal epizootic, such as rabies, in a gh population of susceptibles such as existed in this town.

The town of Hamden in Delaware County had reported cases of bies for several years, but only a few were reported in 1955 and ne in 1956. It is apparent that a high fox population was resident this town, and it is very possible that reintroduction of the disease m adjoining towns might result in a severe epizootic. It should be ted, however, that reporting of fox rabies from this town is known have been especially poor because of its isolation from laboratory ilities available for rabies diagnostic work.

The relatively low fox population in Rensselaer County cannot be dily explained from the information at hand, although it is possible t an epizootic other than rabies may have depleted the foxes in s area. An outbreak of canine distemper could easily reduce a pulation and would very likely pass unnoticed, as might other logic factors.

The data from Columbia County for 1956 have been included in ble 2 for the sake of completeness, but have been omitted from the istical analysis because the trapper reported that he felt his traps e being molested. The senior author inspected the trap line with trapper and concluded that this was the case. It was known that tain individuals in the area opposed the study on the grounds that it erfered with fox hunting.

A potential weakness in this type of census technique is the fact t all trappers engaged in such a program will not be of equal ability. wever, under the rigid system employed in this study of assigning number of traps used and limiting the manner in which they were it is felt that this variable was reduced to a minimum. The time the trapping was during the "fall shuffle", i.e., the period when

family groups are breaking up and the young are establishing
ranges. Layne and McKeon (1956) considered fall data based
trap nights per fox unreliable. Sheldon (1950) gave data on
recapture of tagged and released foxes indicating that the mean
tance traveled by those individuals trapped during or after the
persal time is about 3 to 4 miles, although a few individuals trav
much further. Because such temporary extensions of range mi
by chance, be self compensating, i.e., as likely to increase as to decr
populations, and because all trapping was done nearly simultaneo
fall-collected data were considered valid in this study. Red or
foxes were not differentiated in considering the data since appare
the ratio of reported cases of rabies in each species was about the s
as the ratio of the species taken during this program (Parker, un
lished data).

Weather conditions as noted on the daily trapping records
not considered in calculating the data except in the few instances
heavy rain rendered the traps inoperable in the opinion of the trap
and the catches of all species the following day were none or extre
low compared with those on other days in the same area. All data
the one day involved were excluded in such cases.

It should be noted that much higher populations were, in gen
found in areas free of rabies than in the infected areas. Undoub
rabies had reduced the population in the infected areas to a
extent, but perhaps other unknown ecologic factors played an im
tant role in limiting populations in these areas. While two of the
considered infected (Areas 1 and 2) had been previously trappe
1956, the pressure had not been sufficient to eliminate the disea
foxes entirely. Both this trapping and the presence of rabies
reflected by the low population densities in the towns of Catherine
Reading in Schuyler County for 1956. None of the towns had
trapped previously in 1955, although several had been trapped in
years. Rabies was probably a factor in the population changes sh
by several of the towns in the enzootic area; those in the rabies
areas were remarkably similar in both years.

The probability of trapping a clinically rabid fox is consid
slight since the trapping technique employed depends on olfa
(scent) stimuli. Although this fact may have influenced the cat
foxes in the rabies-enzootic region, it was not felt to have altered
data materially. The number of foxes not susceptible to scent st
must, by logic, be very low at any given time except in a very

nating epizootic of rabies and, though meager, the evidence from w York State available to the authors supports this contention. is, of course, possible to trap a fox during the incubation stage of disease and such an animal might later show clinical signs of the ease while in the trap.

From the data gathered, the Mohawk and Hudson Rivers appear act as natural boundaries preventing the spread of rabies to the rth and east, respectively. In addition, the control-trapping activities ntioned earlier are intended to prevent the spread of the disease the west by maintaining an area of low fox population. Rabies-free as 9 and 10 are east of the Hudson River; 12 and 13 are west of artifically maintained area of low population; and 14 is north of Mohawk River. Only Area 11 lies inside these natural and man-de barriers to the spread of the disease, and this area may become ected as indicated by the one case reported in 1956.

CONCLUSIONS

The census technique described for determining relative fox pulation densities, based on a standard number of traps per unit land area with restrictions imposed to assure adequate coverage of area, is considered to afford a reliable comparison of the popula-ns in various areas of New York State. It appears that, while a h population of susceptibles is necessary for an explosive outbreak rabies (epizootic), a low population level is capable of sustaining enzootic of the disease. In view of the high populations of foxes areas adjacent to the enzootic region it must be assumed that certain logic barriers must exist which apparently limit the spread of the ase. It is apparent that natural and man-made barriers do exist it is possible that other unrecognized barriers also exist. Until n time as additional factors are demonstrated those existing must credited with preventing the spread of rabies.

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EXPERIMENTAL USE OF RESERPINE TO CONTROL CANNIBALISM AMONG RING-NECKED PHEASANTS[1]

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ABSTRACT

Reserpine was fed to 2-week-old pheasants held in battery brooders fl
period of 2 weeks, in concentrations of 5 and 7 milligrams per kilogram
food. Both picking and scalping were effectively reduced. The groups
reserpine ate slightly less food but gained slightly more weight than the cont

The growing popularity of controlled shooting has resulted
the establishment of many hundreds of shooting preserves in the
three or four years (Fournier, 1954). Demands for controlled shoo
and the recent interest of several states in field trials and in a
pheasants for "put and take" stocking (Allen, 1956, pp. 438-4
have required the production of increasing numbers of adult r
necked pheasants *(Phasianus colchicus)* on both public and pri
game farms.

Cannibalism, or feather picking, is one of the most troubles
problems in raising game birds. Dickey (1956) stated that it
driven more game breeders out of business than any other factor.

Picking is most serious at two stages in the rearing of pheasa
(1) when young birds from 2 to 6 weeks of age are crowded in bro
houses, and (2) when adults are crowded in covered holding y
Methods of reducing cannibalism, such as darkening brooder ho
smearing injured birds with anti-pick remedies, bill clipping, "s

[1] Grateful acknowledgment is made to Dr. G. B. Belloff of CIBA Pharmace
Products, Inc. for advice and for providing the reserpine (Serpasil) a
Richard E. Reynolds, game farm foreman of the New York State Cons
tion Department, for providing pheasants, brooder facilities and othe
sistance.

les" and "bits" in the nares, prevention of overcrowding, and pro-ion of heavy cover in holding yards, are either inefficient, difficult very expensive.

Studies of behavior in crowded populations of many species of ds and mammals including man indicate that overcrowding often ises stress which may manifest itself through restlessness, emigration, stility, nervous ailments, or other physiological changes (Errington, 54; Leopold, 1933; Michael, 1949; Selye, 1946; and many others). ather picking among game birds in captivity may be but a manifesta-n of nervous tension caused by social competition and stress from overcrowded environment.

Recent experiments with various tranquilizing drugs of three gen-l types—reserpine, chlorpromazine, and meprobamate—have proven effectiveness of these substances in reducing hypertension. Reser-ne, an alkaloid derived from the root of *Rauwolfia serpentina,* has en used experimentally and clinically on a number of species includ-monkey, dog, cat, rat, mouse, guinea pig, and pigeon (Earl *et al.,* 55; Norton and de Beer, 1956; Plummer *et al.,* 1955; Stein, 1956; l others).

In the preliminary experiment reported here, reserpine was tested clinical doses as a means of controlling picking in young pheasants red in brooders.

METHODS AND PROCEDURE

Experiments on the behavioral effects of tranquilizers have been ed in general on parenteral dosage. With a view to the possible of reserpine in commercial pheasant rearing, oral administration he drug was indicated.

An attempt to administer crystallitive reserpine (Serpasil) by olving it in drinking water was unsuccessful because of its very low ubility. Quantities as small as 5 milligrams were not readily soluble gallon of cold water.

Reserpine was mixed with crumbled chick starter ration in con-trations varying from 5 to 20 milligrams per kilogram of food. mixes were prepared in 200-gram lots thoroughly mixed in a food nder. Premixes were then mixed with food in a commercial food er.

Healthy 2-week-old pheasants were selected at random from stock he Ithaca Game Farm. Both sexes were represented, but the sex o in the samples was not recorded. Ninety birds were placed, in ips of 30, in three standard battery brooders, constructed of half-

inch hardware cloth, each measuring 74 by 27 by 9½ inches. T crowding of 30 birds on less than 14 square feet most certainly p duced conditions of social stress much more acute than appear normal brooder operation. The room was not darkened, nor wa force-ventilated. Brooders were heated to a thermostatically contro temperature of 92° Fahrenheit. Constant illumination was provi by a 15-watt bulb. Water was available in unlimited quantity. Fo consisting of crumbled starter ration, was available to the birds at times. Each group was weighed collectively.

Group A received reserpine at the rate of 10 milligrams per k gram of food; Group B, at the rate of 20 milligrams per kilogram; Group C, the control, received undrugged food.

Twenty-four hours after the experiment was begun, birds Groups A and B appeared as though doped. Although active w disturbed, no violent fear reaction was apparent as exhibited by control group. When undisturbed, the reserpine-treated birds squat with eyes closed. Their plumage generally appeared rough, as f lack of preening.

After 48 hours, one bird was dead in Group A, and four in Gr B. The alimentary tracts of the autopsied birds were empty. App ently the birds were under sufficient sedation to prevent eating drinking. The food containing reserpine was removed and was repla by untreated ration. On the third day, all remaining birds appea to be normal in activity and plumage. On the fourth day, no furt change was noted in any of the young pheasants.

At this time, four birds were removed from Group C (the trols), and three from Group A, leaving 26 birds in each broo Collective weights of each group were recorded. Following this, Gr A was fed reserpine at the rate of 5 milligrams per kilogram of f and Group B at the rate of 7 milligrams per kilogram. No fur losses occurred during the course of the experiment, and no behavi differences were apparent between the three groups.

Eleven days later, the experiment was terminated. Colle weights of each group were again taken, and the total weight of f fed to each group was recorded. Each bird was examined care for signs of picking, and a score was noted for each, based on sev of picking, according to the following scale. Birds which showe signs of picking were rated zero; on these, the dorsal feather tract complete. Birds showing slight picking were assigned a score of 1; a bird showed only a barely discernible exposed area on the lower b

ose from which less than half of the dorsal feather tract had been moved were scored 2; and those with more than half of the back osed were scored 3.

Since the pheasants had been held in small brooder cages made hardware cloth, some wear of head feathers and "scalping" urred. It may be assumed that feather wear and scalping of the wn directly reflect the strength of the escape drive in pheasants der such conditions. Evidence of scalping was also scored accordly to severity as follows: where no sign of wear of crown feathers evident, zero; light, medium, or heavy wear of crown feathers re rated 1, 2, or 3, respectively; where the head had been skinned, recorded score was 4.

RESULTS

Careful examination of reserpine-treated chicks revealed no evince of physiological changes, such as the pupillary constriction orted in dogs and monkeys by Plummer *et al.* (1955). The birds d in this experiment were placed in holding yards with other game n stock. No after-effects from treatment with reserpine were noted.

KING AND SCALPING

Based on the scoring system described, the intensity of picking and ping in each group was expressed as the percentage obtained of total possible score (Table 1).

TABLE 1. INTENSITY OF PICKING AND SCALPING AMONG RESERPINE-TREATED PHEASANT CHICKS COMPARED WITH THAT AMONG UNTREATED BIRDS

oup	Number of birds	Dose*	Score	Per cent of maximum possible score	Number severely picked or scalped
			Picking		
A	26	5	8	10	0
B	26	7	25	32	3
C	26	0	53	68	15
			Scalping		
A	26	5	19	18	0
B	26	7	26	25	0
C	26	0	46	44	5

* In milligrams per kilogram.

Food Conversion

It was apparent at the conclusion of the period of treatment, t the controls had used more food than either of the experimental grou and had gained less weight. The average quantity of food used by ea group, the average gain in weight, and an index of food convers for each group appears in Table 2. These results indicate that reserp

Table 2. Food Conversion in Reserpine-treated Pheasant Chicks C pared with that in Untreated Birds

Group	Number of birds	Dose*	Food consumptions§	Weight gain§	Food consumed per gram gained
A	26	5	289	116	2.5
B	26	7	323	135	2.4
C	26	0	342	110	3.1

* In milligrams per kilogram.
§ Average in grams.

may improve food conversion. However, the data are inconclu because individual weights before and after treatment were obtained, and because the recorded quantities of food used incl small amounts kicked out of the feeders.

DISCUSSION

Picking and scalping were effectively reduced in young pheasa held under brooder conditions which aggravated picking activ Results of this small experiment are sufficiently encouraging to jus more extensive experimentation with the various tranquilizing d on species that are important in game farm operations.

The administration of reserpine in small doses, up to 7 milligr per kilogram of food, appears to have no harmful effects on yo pheasants. Plummer *et al.* (1955), reporting on the pharmacolog reserpine, stated that there is a latent period of from 1 to 2 h before any effect is seen, whether reserpine is administered orall by intravenous injection. In our experiments, pheasants returne normal within 24 hours after drugged food was removed.

With regard to toxicity of reserpine, Plummer *et al.* (1955) st that it ". . . is rather low. Monkeys have tolerated single oral d up to 400 mgm. per kgm. (of body weight) and rats have rece doses up to one gram per kgm. No untoward effects were produ

these doses. Profound sedation occurred but recovery was complete
ll cases". The author has fed reserpine to adult pheasants, in doses
to 40 milligrams per kilogram, without obtaining noticeable
ation.

For oral administration, reserpine (Serpasil) has the advantage
being tasteless. Experiments now in progress with meprobamate on
ks indicate that the extreme bitterness of this substance may present
e problems of administration.

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GENERAL NOTES

A TECHNIQUE FOR DE-SEXING TROUT[1]

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The normal life span of brook trout is of interest in connection v management in New York waters. R. G. Zilliox[2] has reported that, e under favorable conditions, 4-year-old brook trout are rare and that in s waters 3-year-olds are few in number. The short life hampers the develop of really large individuals, and makes the majority of brook trout availabl the angler for only two fishing seasons.

Meager data suggest that one of the factors affecting longevity may sexual activity. For example, several years ago a small lot of brook trout studied at the Cortland Hatchery throughout their entire life (Tunison *et* 1938). At the third spawning, a mortality started which persited through the following year. A. V. Tunison[2] stated that the mortality consisted m of male fish. Within a few weeks of the next spawning season, the remain of the group, primarily females, succumbed.

Outbreaks of either furunculosis or ulcer disease are quite common hatchery brood stocks at spawning time, in fish which were "healthy" the of the year, even though furunculosis, at least, is considered a disease us associated with high summer temperatures. Perhaps the energy used in spa ing weakens the general condition of the fish, and thereby reduces its resista not only to disease but to any adverse condition.

In a natural environment, winter mortalities of brook trout are know be high. Since "winter" includes the spawning season it may be specul that weakening of the fish due to spawning may be a contributing facto these mortalities.

In order to test the effect of spawning on longevity, a technique has b developed to remove the sex organs of 5- to 8-inch brook trout. A tro anesthetized, and a ¼-inch longitudinal incision is made into the body ca just below the ribs and near the end of the pectoral fin when it is in a no position against the side of the body. The center portion of the sex orga pulled out through this opening with a small metal hook.[3] While held in manner, the organ is grasped with tweezers in front of the hook and its f end is severed at its point of attachment by a sharp tug. It is then gra in back of the hook and severed in the same manner. A similar procedu then employed on the other side of the fish. The operation is much e on the left side than on the right due to placement of other organs. On right side a second incision is sometimes necessary on females, this incision b vertical and just back of the gill opening. Complete failure will occasio occur in de-sexing, but mortality due to the operation is extremely low. incision heals rapidly.

During July 1955, seven brook trout were de-sexed by this method held in a pond at the South Otselic Hatchery until November 1, 1955, w the pond was drained. Four, a male and three females, were recovered examined. The male had a very small remnant of the testis left. In females, only a very few, very small eggs were found, and no ripe ones. most eggs per fish was estimated at 40 to 50. The incisions had h completely. One adhesion of an internal organ to the incision was noted.

In December (1955) 320 brook trout were de-sexed, and kept u observation in the hatchery until April. Mortality during this period

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[1] Thanks are due D. A. Boardman, Jr., D.V.M., who assisted in developing technique for de-sexing.

[2] Personal communication.

[3] A ladies' glove button hook worked well.

ut five fish. Among the males, it is believed that removal of the organ s complete in about 90 per cent. For the females, the degree of success highly variable; the organ was very fragile and sometimes broke in the ddle of the egg sac.

This method is suitable for experimental purposes only, and is intended use in investigations of the effect of sex on growth and longevity. The unt of work involved would make its use impractical for even limited tine stocking purposes. In experimental groups, the proportion of fish ctively de-sexed can be held high by discarding doubtful specimens. Even ong the latter, mortality is low and they may be returned to the original k.

Further experiments are planned both at the Cortland Hatchery and under ural conditions in an Adirondack pond.

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PHEASANT NESTING SUCCESS ON AN AREA IN WESTERN NEW YORK[1]

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Pheasant nesting success was studied on a 900-acre tract in Monroe County ing May and June of 1953. The area[2] within which this tract is situated onsidered typical of much of the intensively farmed Ontario plain, where tively safe nesting cover such as weed fields, roadsides, ditchbanks and te areas constitute only a very small part of the total acreage—about 7 cent in the case of this sample tract. In addition, some 48 per cent of tract provided cover suitable for nesting but subject to agricultural dis- ance, e.g., alfalfa, hay, and the cover crop (usually red clover) sown with ter wheat harvested the previous fall. The principal forage crop in this on is alfalfa which, depending upon weather conditions, usually provides e cuttings between late May and early September. The small amount of thy hay produced is usually cut in late June, but where it is used for s silage the date of cutting is advanced considerably. The spring plowing wheat stubble takes place between May 1 and June 10, again depending n the condition of the ground.

All cover which might provide pheasant nesting sites was searched inten- ly. In the case of hay and alfalfa fields, close track was kept of the able mowing dates, and one man followed the mower whenever possible. his could not be done, the fields were stripped after mowing by two men ing about 6 feet apart. The wheat stubble and other cover were stripped by men working about 40 feet apart, brushing the intervening cover with oot bamboo poles.

Locations of all active and inactive nests found were plotted on maps of tract. For each active nest the number of eggs when found was recorded,

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3,500-acre area near Henrietta used for other pheasant investigations.

and it was checked again after the probable hatching date to determine outcome. Inactive nests were examined carefully to determine the proba cause of failure.

Twenty-four nests were located. An analysis of these as to fate and co type is given in Table 1.

Table 1. Fate of 24 Pheasant Nests on Study Area in Monroe Coun in 1953 and Cover Types Used

Fate and cause of failure	Number	Per cent	Cover type		
			Alfalfa	Hay	Wheat stubl
Successful.....	3	12.5	1	..	2
Unsuccessful...	21	87.5	9	5	7
Total	24	100.0	10	5	9
Destroyed by:					
Mowing.....	12	50.0	8	4	..
Plowing.....	7	29.1	..	..	7
Flooding.....	1	4.2	1	..	..
Predation....	1	4.2	..	1	..

During the course of other concurrent pheasant studies, the breed population and the number of broods produced were estimated for the en 3,500-acre Henrietta area each year from 1951 through 1953. The relati ship of the number of hens to the number of broods produced is given Table 2.

Table 2. Relationship of Number of Pheasant Hens during Spr and Number of Broods Produced on Henrietta Area, 1951 1953

Year	Hens	Broods	Ratio*
1951	308	85	27.6
1952	350	64	18.3
1953	329	48	14.6
Total	987	197	20.0

* Percentage relationship to number of hens in breeding population.

The rate of success for the 24 nests studied in 1953 seems very low, the volume of data represented is admittedly small. However, this rate did differ greatly from the ratio of broods to hens shown in Table 2 for the sa year. Furthermore, the latter would include any successful renestings, w the other would not. Thus, it may have been fairly typical of the Henri area as a whole, and, perhaps, of much of the Ontario Plain region.

All of the pheasant nests under study in 1953 were located in cover wh due to existing farm practice, afforded rather poor prospects for success. T cover types occupied about 48 per cent of the tract, while most of the remai was in cultivated crops, pasture and woods that did not afford nesting co for pheasants.

COMPARATIVE CHANGES IN PHEASANT BROOD NUMBERS AND BROOD SIGN ON THE SAME AREA[1]

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From 1951 through 1953, an estimate was made each year, based on field
k throughout the summer, of the number of pheasant broods on a 3,500-
area in Monroe County (N. Y.). Also, each summer during the same
od, pheasant brood signs—tracks, droppings, dust baths, and feathers—
recorded along the 70 miles of field borders on the area. The latter
se of the work required 20 man days per year and was done in a similar
ner each time.

LE 1. Concurrent Changes in Estimated Numbers of Broods Produced and in Brood Signs Recorded

Year	Broods produced		Brood signs	
	Number	Per cent change	Number	Per cent change
1951	85	..	106	..
1952	64	−24.7	68	−35.8
1953	48	−25.0	37	−45.6

The two sets of data are given in Table 1 together with the degrees of
ge from year to year. Comparison of these figures is of interest with
ect to the extent to which the sign records, which were obtained by a
oling procedure, represented an index of the trend in brood production
he area. In both cases, a progressive decline was evident. But the degree
hange indicated by the sample data was considerably greater than that
n by the actual population estimates.

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